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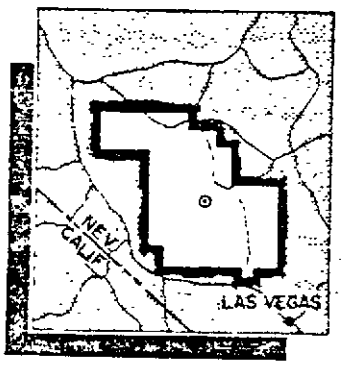
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1 Dec. 53

Operation UPSHOT-KNOTHOLE

NEVADA PROVING GROUNDS

March - June 1953

REPORT OF THE DEPUTY TEST DIRECTOR



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LOS ALAMOS SCIENTIFIC LABORATORY
UNIVERSITY of CALIFORNIA

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Date: 13 Sep 94

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REPORT OF THE DEPUTY TEST DIRECTOR

By

John C. Clark

Los Alamos Scientific Laboratory
Los Alamos, New Mexico
June 1954

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CHAPTER 1

ESTABLISHMENT OF TESTS

1.1 PRELIMINARY PROPOSALS

Toward the end of Operation Tumbler-Snapper in the spring of 1952, it appeared quite likely that the Los Alamos Scientific Laboratory (LASL) would require a continental test series soon after Operation Ivy, which was to be held in the Pacific in the fall of 1952. This series of tests was to be known as "Operation Upshot," and the earliest test date appeared to be the spring of 1953.

The Department of Defense (DOD) had independently planned to make military effects tests on an atomic weapon, and this operation was designated "Knothole." The Federal Civil Defense Administration (FCDA) participated to a small extent in Operation Tumbler-Snapper and at that time had plans to make full-scale "open" shot tests utilizing an atomic weapon specifically assigned for this purpose. With the proposed Operation Upshot scheduled for the spring of 1953, both the DOD and the FCDA accelerated their planning with a view in mind that their tests might be coordinated with Operation Upshot, in the matter of time at least.

After Tumbler-Snapper the DOD made a very desirable change in their organization by establishing the Directorate, Weapons Effects Tests (DWET) under the Field Command, Armed Forces Special Weapons Project (AFSWP), Sandia Base, N. Mex. DWET would provide the direct liaison between the DOD and the Santa Fe Operations Office (SFOO) of the Atomic Energy Commission (AEC), the headquarters of the test organization, both for accomplishing the military effects tests and for providing military services as required by the test organization.

1.2 LABORATORY, DOD, AND CIVIL GROUP PARTICIPANTS

By June 1952, agreements were reached by the AEC and DOD that the spring 1953 tests would be a combined operation known as "Upshot-Knothole"; and at the same time the FCDA had ascertained that their budget would not accommodate a full-scale FCDA test, and they planned only to participate to some extent in the AEC-DOD tests. On the basis of what appeared to be the scope of the tests involved in Operation Upshot-Knothole, the Test Director held discussions with representatives of the groups involved, and by the first of September 1952 the organization shown in Fig. 1.1 was decided upon. The FCDA tests would be included in the Civil Effects Tests, with key FCDA representatives acting as certain program directors.

1.3 TEST SCHEDULE, SEPTEMBER 1952

As of Sept. 1, 1952, the nuclear devices to be tested in Upshot-Knothole were not at all firm, but it appeared likely that LASL desired to test at least five devices, the newly formed

[redacted]

University of California Radiation Laboratory (UCRL) at Livermore, Calif., would have two devices, the DOD would want one [redacted] for their principal military effects tests, and there was a possibility that the Army Ground Forces would request that the [redacted] Mk-9 (gun) type gadget be fired from the 280-mm cannon. It was also clear at this time that the Ground Forces, under the command of the Sixth Army, would participate in tactical exercises in an operation known as "Desert Rock V." The FCDA had already started pressing for one of the tests in the series to be an open shot to which the FCDA would invite a reasonable number of uncleared personnel, including the press and key state and city FCDA personnel.

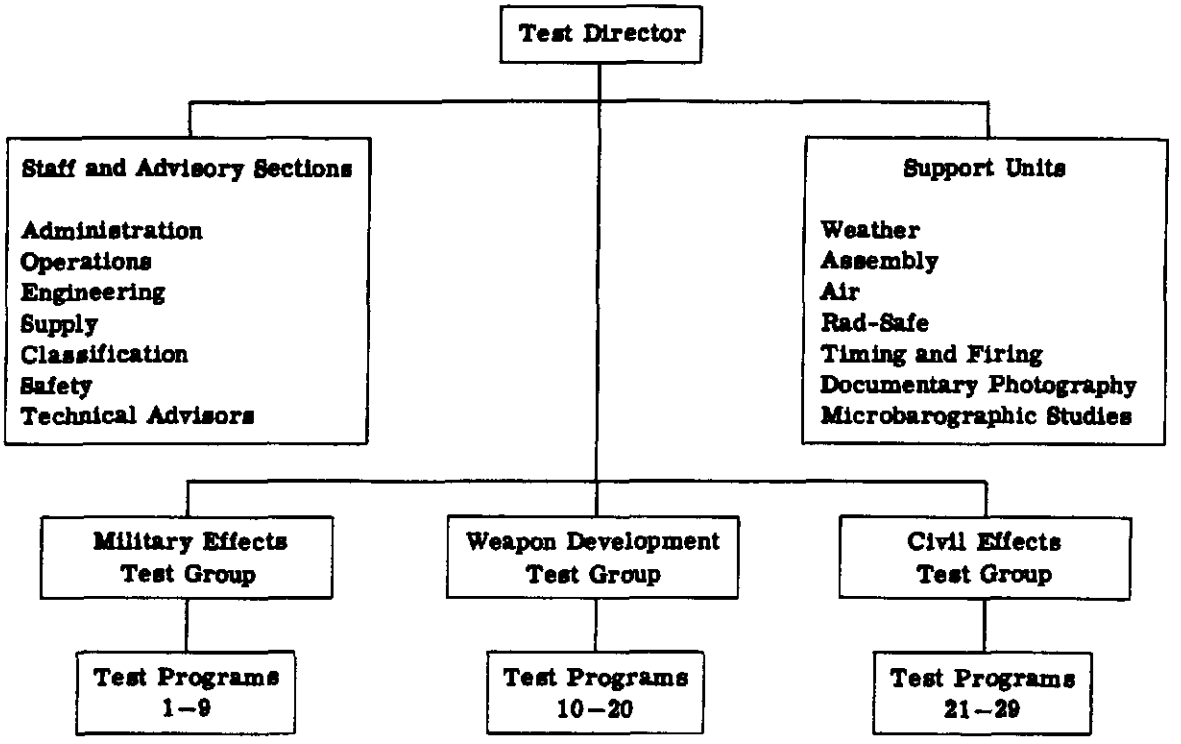


Fig. 1.1—Test Director's organization.

On Sept. 16, 1952, at the second staff meeting of the Test Director (reference J-14484, LASL internal document), the test schedule shown in Table 1.1 was announced as tentative for planning purposes.

The plan for firing these devices was to utilize tower and airdrop areas in Yucca Flat for all except the Effects shot, and, since the test program for this shot involved a several million dollar construction schedule including considerable blast measurements to be correlated with the Tumbler-Snapper data, it was decided to utilize Frenchman Flat for the DOD test. It will be remembered that the first Tumbler-Snapper shot was a military effects test conducted on Frenchman Flat, and the plan was to utilize as much as possible of the existing instrumentation and cable installation from that test.

The schedule underwent several changes as LASL, UCRL, and DOD planning progressed. By early October the [redacted] Mk-9 (gun) device had received DOD approval, and negotiations were started between the DOD and the AEC to include it in the test program, to be fired at the end of the test series over the Frenchman Flat target area. Also, UCRL was seriously considering eliminating the [redacted] device from Upshot-Knothole and substituting a device similar to the [redacted] to be known as [redacted] Likewise, the [redacted] devices proposed by LASL were undergoing discussion and were subsequently dropped from the program.

[redacted]

Table 1.1—TEST SCHEDULE AS OF SEPT. 16, 1952

Device	Later name	Proposed test date	Sponsor
[redacted]	[redacted]	3/3/53	LASL
		3/10/53	UCRL
		3/17/53	UCRL
		3/23/53	LASL
		3/27/53	LASL
		4/1/53	LASL
Effects		4/6/53	DOD
[redacted]	[redacted]	4/11/53	LASL
		4/18/53	LASL

Table 1.2—TEST SCHEDULE AS OF DEC. 16, 1952, SHOWING PROPOSED FIRING DATES

Description	Device	Proposed firing date	NPG area	Burst height, ft	Type of shot	Sponsor	Purpose of test
[redacted]	[redacted]	3/17/53	3	300	Tower	LASL	[redacted]
		3/24/53	4	300	Tower	LASL	
		3/31/53	7-5a	300	Tower	UCRL	
		4/6/53	7-3	6150	Air	LASL	
		4/11/53	2	300	Tower	LASL	
		4/18/53	4a	50	Tower	UCRL	
		4/25/53	1	300	Tower	LASL	
		5/2/53	3a	300	Tower	LASL	
		5/4/53	F	2420	Air	DOD	
Effects		5/7/53	F	2420	Air	DOD	Weapon effects test on structures and materials
Gun	Mk-9	5/21/53	F	500	Air	DOD	Proof test of Mk-9 weapon
[redacted]	[redacted]	6/4/53	7-3	1350	Air	LASL	[redacted]

* This device was added to the test series in May 1953

[redacted]

It should be pointed out here that tower and blockhouse construction had necessarily already begun, and it was only due to the great versatility of the permanent facilities at the Nevada Proving Grounds (NPG) that late changes in devices to be detonated could be accommodated without changing the firing dates.

During this period the Test Director's staff met on several occasions with representatives of the three test groups, reviewing their programs and test requirements. The plan of this office was to get both the schedule of shots and the experimental participation of test groups in the various shots firmed up well enough by the middle of December 1952 so that an operations plan for Upshot-Knothole could be presented for approval to the Test Manager and the Division of Military Application (DMA) of the AEC.

1.4 TEST SCHEDULE, DECEMBER 1952

The devices to be tested in Upshot-Knothole were firmed up by the middle of December 1952, as shown in Table 1.2. This table gives the firing dates as proposed on December 16.

The shots were scheduled so that (1) no detonation came on Sunday; (2) the tower shots were one week apart; and (3) the interval between a tower and an airdrop was four days minimum and the time between the Effects and Gun shots was a minimum of two weeks. The "no Sunday" scheduling was made at the request of the Test Manager and was based on the number of complaints received on this subject during previous continental tests. The one-week interval between tower shots was based on the time required by Edgerton, Germeshausen & Grier (EG&G), alpha, photographic, and timing groups to change test locations and also to provide a one-day rest period each week for test personnel. The two-week interval between the Effects and Gun shots was at the request of the Military Effects Test Group so that they could evaluate properly the Effects shot damage and reactivate certain stations before the Gun shot over the same target area.

CHAPTER 2

SCOPE OF TEST REQUIREMENTS

An LASL letter* contains a detailed discussion of the purpose for each of the LASL-sponsored tests, and Report UCRL-4011(Revised) contains a similar discussion of the UCRL-sponsored tests. However, in order to establish the scope of the test requirements, the test organization, and operational procedures, a very brief description of the purpose of each test will be included here, along with the required measurements.

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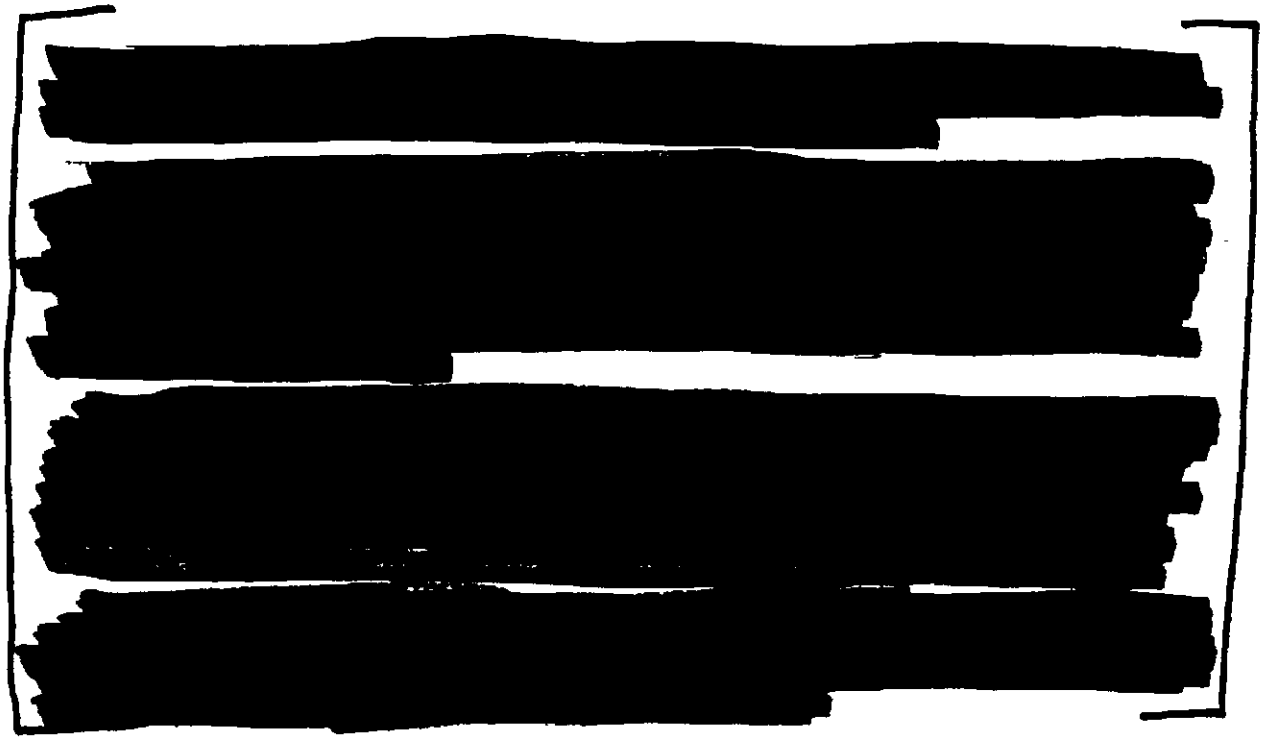
2.1 DESCRIPTION OF TESTS

[redacted]

*Letter from the Director, LASL to DMA, AEC, Jan. 6, 1953, CX-763-9A.

[redacted]

Pages 14, 15 and 16 are deleted.



2.1.8 Effects

(a) Purpose. The purpose of this test was to detonate a standard weapon at a scaled height which duplicated that for the Tumbler 1 shot on Frenchman Flat and with this detonation to conduct numerous tests of specific interest to the DOD. These tests ranged from fundamental blast and radiation studies to the effects upon structures and material. There developed during the operation what might be termed a secondary purpose to the test, of interest to both LASL and the DOD

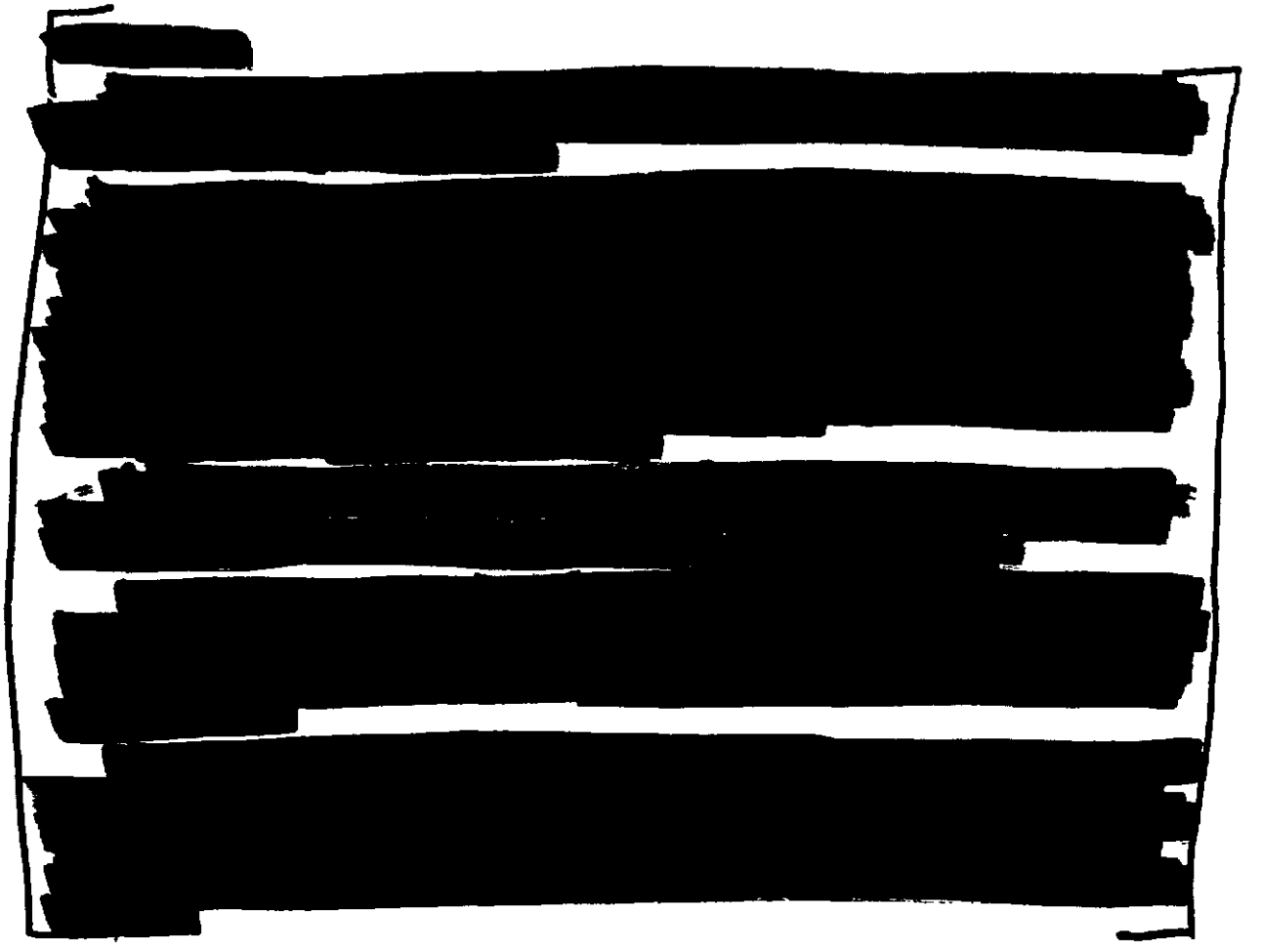
(b) Device.

(c) Required Measurements. The required weapon development measurements were yield and alpha, although in the military effects tests certain blast and photographic measurements were of higher priority than the alpha measurement.

(d) How Detonated. The Effects shot was to be an airdrop with burst height at 2450 ft and with surface meteorological conditions at the target area such that certain blast measurements could be made. Also, since there were to be some 200 cameras photographing the motion of structures during the detonation, it was necessary to have sufficient daylight. The time of 0830 PST was decided upon as being late enough to give sufficient photographic light but not too late to prevent the radioactive cloud from being followed to a relatively low background before nightfall.

(e) Schedule. The preoperational schedule provided for the shot to follow the and then the Effects and Gun shots in Frenchman Flat. However, heavy ground contamination in Area 3a around the tower prevented instrumentation from proceeding on schedule; therefore it was necessary to delay 2 days.

It was not easy to change the firing date of the Effects shot, but it was possible to change the necessary instrumentation so that could be fired between the Effects and Gun shots.



2.1.10 Gun

(a) Purpose. The [Mk-9] gun weapon, developed for use in the Army's 280-mm cannon, had not been proof tested, and the DOD desired such a test. Although this nuclear assembly was the same as that used for the Hiroshima drop, measurements of alpha and yield had never been made, and LASL desired to make such measurements. For the weapon development measurements it would have been more desirable to have a tower detonation so that alpha detectors could be placed nearby the device and an early alpha guaranteed. However, compromise agreements were reached to have the burst at 500 ft above terrain and thus assure the proof test as well as a reasonably complete alpha record.

(b) Device. This device was the [Mk-9] weapon. The [Mk-9] atomic shell was launched from the 280-mm artillery piece.

(c) Required Measurements. The required measurements for the [Mk-9] were yield and alpha. In addition, the Military Effects Test Group was conducting a rather elaborate set of military effects experiments, and a high priority was placed on fundamental blast and radiation measurements, with requirements for rather exacting meteorological conditions.

(d) How Detonated. The [Mk-9] shell was launched from the 280-mm cannon placed 10,956 yd from the target, with burst height set for 500 ± 100 ft above the Area F target and with an accuracy in range of ± 150 ft. The latter requirement originated with the alpha-measurement group.

(e) Schedule. The requirement of the Military Effects Test Group was that the time interval between the Effects and [Gun] shots be a minimum of 13 days. This was to allow for



evaluation of the Effects shot results on structures and to allow for reinstrumentation of Area F in order to make measurements on the Gun shot properly.



2.2 PARTICIPATING AGENCIES

In the foregoing sections of this report, we have presented the schedule of nuclear tests which were proposed, along with the purpose of each test and the measurements required to ensure fulfilling the purpose. In addition to the required measurements, there were many other experiments, military training programs, civil defense indoctrination programs, and national press and official visitor activities which became involved in the test operations. These activities were not minor in scope, and, although they were nearly always permitted and included in the program on a noninterference basis, they involved considerable operational and test planning on the part of the Test Director's staff so that they did not, in fact, interfere either with the required test measurements or the primary test operations. These extra experiments and test activities will be discussed only as they affected the operation.

2.2.1 Military Effects Test Group Experiments (Programs 1 to 9)

The Military Effects Test Group was concerned primarily in making measurements on the DOD-sponsored tests, namely, Effects and Gun shots. However, this group was concerned, in general, with making measurements on any nuclear test, when feasible, in the following categories and as the effects pertain to military planning and operations:

Program 1, Blast and Shock Measurements: Measurements in free air, on the surface, and in the earth. These include basic air-blast measurements for use in compiling height-of-burst data as well as interpreting blast effects on structures, military equipment, and material.

Program 2, Nuclear Measurements and Effects: A program including neutron and gamma flux measurements and airborne particulate studies.

Program 3, Structures, Material, and Equipment: This program involves the study of blast and radiation on model as well as actual structures and on material and equipment of particular interest to DOD.

Program 4, Biomedical Experiments: Experiments which included the evaluation of the hazard of flying through an atomic cloud (utilizing the drone aircraft of Program 5), air-blast injuries, flash blindness, and the measurement of hazards in fall-out areas.

Program 5, Drone Program: A program wherein instrumented drone aircraft were used for blast, thermal, and air-gust studies on aircraft at levels where manned aircraft were considered to be hazardous.

Program 6, Test on Service Equipment and Operations: A program involving mostly the evaluation of service equipment and operational techniques for use in atomic warfare.

Program 7, Long-range Detection: A program involving the remote detection of nuclear detonations by light, sound, electromagnetic, seismic, and radioactive-debris methods.

Programs 8, Thermal Measurements and Effects: A program including basic thermal measurements and thermal effect on service material.

Program 9, Technical Photography: A program which involved the photographic coverage of the above test programs.

The administrative procedure employed by the DOD and test organization to accomplish the military effects tests is as follows:

The military effects test programs originate with AFSWP, which obtains test proposals from the various military agencies. AFSWP integrates and coordinates the proposed program with the predicted characteristics of the device to be tested. The program is then presented to the Research and Development Board (RBD) of the DOD for approval before being forwarded by AFSWP, Washington, to DWET, Sandia Base. It then becomes the responsibility of DWET to implement the program and carry out the tests. The philosophy of the Test Director is not to screen the DOD tests for their effectiveness or value but rather to coordinate this test program into the over-all test operation, and it is only from an operational standpoint that an experiment is questioned.

The detailed military effects test program is given in the test participation chart in Appendix A of this report.

2.2.2 Weapon Development Test Group Experiments (Programs 10 to 20)

The Weapon Development Test Group is responsible for making the tests originating from the purpose of the test (when it is a weapon development test), for conducting such other basic tests of nucleonics which are of use in weapon development work, and for conducting exploratory experiments on new measurement techniques. In general, these tests fall into the following categories:

[redacted]

[redacted]

[redacted]

2.2.3 Civil Effects Test Group Experiments (Programs 21 to 29)

A new test group was introduced for Upshot-Knothole, primarily because, for this operation, agencies in the AEC as well as the FCDA proposed experiments and the nature of the proposals was sufficiently different from those in the military effects or weapon development categories to warrant establishing what was called the Civil Effects Test Group. The Test Director named a director of tests for this group, and it was his responsibility to coordinate the test proposals in this category and, acting for the Test Director, to screen them for operational feasibility and scientific usefulness to the agency. These experiments were financed entirely by the agencies proposing them. For Upshot-Knothole the civil effects tests were divided into test programs, and details of the individual experiments contained in each program, along with the sponsor, are given in the test participation chart in Appendix A of this report. The Civil Effects Test Group programs were as follows:

Program 21, FCDA Effects Studies
Program 22, FCDA Radef and Radiation Effects
Program 23, Biomedical Experiments
Program 24, AEC Shelter Structures
Program 25, Unassigned for Upshot-Knothole
Program 26, Civilian-vehicle Tests
Program 27, Fall-out Studies in Near Areas
Program 28, Radiation-telemetering Systems
Program 29, Dosimetry and Radiation Measurements

2.2.4 Exercise Desert Rock V

Exercise Desert Rock is the U. S. Army designation for troop participation in continental nuclear tests. Previous exercises in Buster-Jangle and Tumbler-Snapper were designated Desert Rock I, II, III, and IV and for Upshot-Knothole, Desert Rock V. The purposes of the exercises for Desert Rock V may be summarized as follows:

1. To provide indoctrinational training (1) in tactical operations featuring tactical employment of atomic weapons, (2) in essential physical protective measures, and (3) for partici-

[redacted]

pating troops and troop observers in the effects of atomic explosions on displays of equipment and animals (sheep).

2. To demonstrate visually the effects of atomic detonations on field fortifications and other defensive structures.

3. To indoctrinate and measure ability of trained staff officers in the estimation of target damage.

4. To observe the psychological effects on troops participating in the exercises.

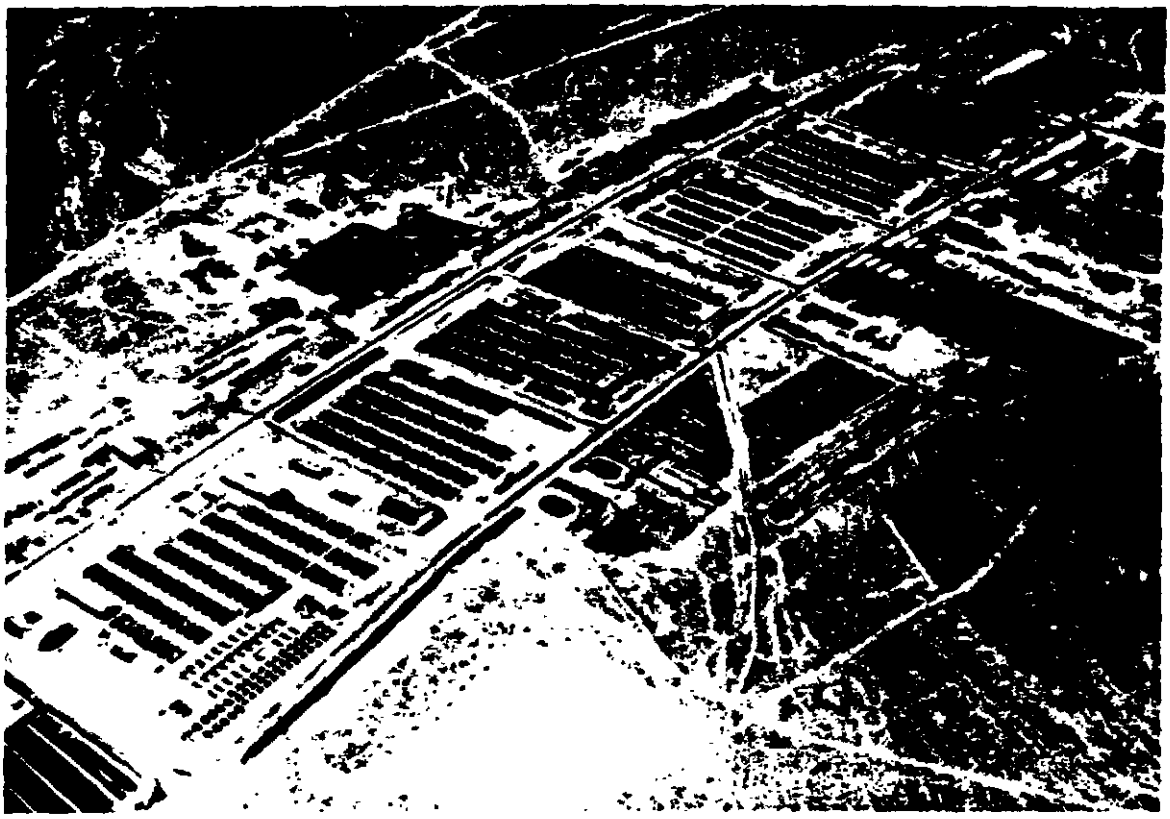


Fig. 2.1—Aerial view of Camp Desert Rock.

The Desert Rock V organization was under the command of the Sixth Army, with headquarters at Camp Desert Rock located 2½ miles from Camp Mercury, the headquarters of NPG. Figure 2.1 is an aerial view of Camp Desert Rock showing tents, storage areas, and permanent buildings at the time of peak activation during Upshot-Knothole. As shown in the Test Manager's organization chart (Fig. 3.2), the Desert Rock exercises were integrated into the test organization through a liaison officer on the staff of the Test Manager's Deputy for Military Operations. The Test Director's responsibility in the exercises was only that of integrating the exercises into the test operations. This responsibility was not minimal, however. The Desert Rock V exercises involved participation in 9 of the 11 shots, with a total of 13,409 troops and 4288 observers, distributed as shown in Table 4.2. These personnel (a maximum of 3259 for any one shot) were moved from Camp Desert Rock into the entrenchment areas located between 3500 and 5000 yd from Ground Zero by 1 hr before detonation, and after the shot they proceeded overground in various formations from the entrenchments to near zero before returning to their quarters at Camp Desert Rock. In addition, there were paratroop and helicopter operations on several of the shots. The ground area between the troop entrenchments and Ground Zero was instrumented with service display equipment, defensive structures,

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and animals for observation by the troops before and after the detonation. It was the Test Director's responsibility to integrate these operations into the over-all operations.

Details of the Desert Rock V exercises are contained in the report entitled "Exercise Desert Rock V" and in brief form in Chap. 5 of this report.

2.2.5 Documentary Film of Upshot-Knothole (Lookout Mountain Laboratory)

As in past nuclear test programs, the DOD (and to a lesser extent the AEC) desired documentary films of various phases of the test operations. These films, to be used for indoctrinational and training purposes, were mostly technical in nature, and, since they involved classified information, the organization best suited to make them was the USAF Lookout Mountain Laboratory, Hollywood, Calif. Their activities were made one of the Test Director's support units. A mobile field unit from Lookout Mountain Laboratory participated in each of the shots as well as in the over-all activities of the test organization, and their operations were coordinated through the Test Director's plans and operations staff unit.

2.3 FCDA OPEN SHOT

The FCDA believed that the funds they were expending on test programs in the civil effects tests could best be justified if they were permitted to present the results directly to the public through the press and through a number of observers. Both these groups would consist of uncleared personnel. The subject was presented to the AEC, and concurrence in the plan was given only two and one-half weeks before the actual test date. The Test Director recommended that the first detonation of the test series would be most suitable. As in the case of Desert Rock V exercises, the Test Director had no administrative responsibility for handling the FCDA open shot arrangements, but, because the activities associated with the press involved live television and the influx of a Signal Corps company to provide extra communications facilities, the Test Director became involved. Radio-frequency coordination for the test operation was the responsibility of the Test Director, and the activities of the press necessitated additional power and radio dry runs and checking to make certain that these activities would not interfere with critical experiments.

An open shot with television had been held during Tumbler-Snapper with no ill effects. Since many of the same personnel participated in both open shots, the Test Director experienced no great inconvenience by the FCDA open shot activities in Upshot-Knothole.

2.4 OTHER OFFICIAL OBSERVERS

2.4.1 Cleared Laboratory, AEC, and DOD Observers

It is a policy of the Test Manager to permit a reasonable number of cleared official observers from the weapon development laboratories, the AEC organizations, and the DOD to observe the nuclear detonations. The only responsibility the Test Director has in handling these people at the test site is to provide indoctrination lectures when requested and to assist in conducting these groups through technical installations, such as the control point, target-area displays, and blockhouses in the technical area. These activities do not interfere and are considered very worth while.

2.4.2 Congressional Visitors

During Upshot-Knothole the Chairman of the Joint Committee on Atomic Energy invited all congressmen to witness a detonation and allied test activities for the last four shots of the series. As stated in Sec. 2.4.1, the Test Director provided technical indoctrination and tour guides in the technical areas. These activities caused no interference and were considered beneficial to the test organization, based on congratulatory remarks made by these visitors.

[redacted]

CHAPTER 3

TEST DIRECTOR'S ORGANIZATION

The organization assembled by the Test Director for conducting the Upshot-Knothole series, the scope of which is outlined in Chap. 2, is shown in Fig. 3.1. This is the organization used during the operational phase of the tests and contains the names of the personnel assigned to each of the various functions. The Test Director's organization fits into the Test Manager's organization as shown in Fig. 3.2.

Although the chart in Fig. 3.1 is self-explanatory, a few remarks regarding some of the functions of the various staff and support units should be made here. An explanation of the test groups has already been given in Sec. 2.2.

3.1 TECHNICAL LIAISON UNIT

The purpose of this unit is to advise the Test Director on technical matters pertaining to the tests. During Upshot-Knothole there were new experimental techniques employed; two of the tests were on devices from UCRL and two of the tests were under the control of DIRX, LASL. The three members of the Technical Liaison Unit represented the special interests of these tests and assured the Test Director that the purposes of the tests were being properly fulfilled. In addition, the Test Director called upon other personnel from LASL to do technical liaison work when it was felt desirable.

[redacted]

3.2 CLASSIFICATION AND TECHNICAL REPORTS

There are a large number of classification problems in connection with an operation of this kind. Previous to the operational period of the tests, the Classification Officer provided a classification guide for the Test Director's organization. The guide for Upshot-Knothole, Appendix B of this report, was circulated throughout the organization. The classification guide stipulates that all photographs taken during the operation must be classified by the Classification Officer. To accomplish this rather large task, an office was maintained at the control point by the Classification Officer. This officer also served on the staff of the Test Manager as classification officer and as an advisor to the Public Information Officer.

3.3 SAFETY

The safety for activities at NPG is the responsibility of the Field Manager. However, because the activities of the test personnel included nucleonics, handling special gases, high voltages, high explosives, and often somewhat hazardous positioning of equipment on towers, the

[redacted]

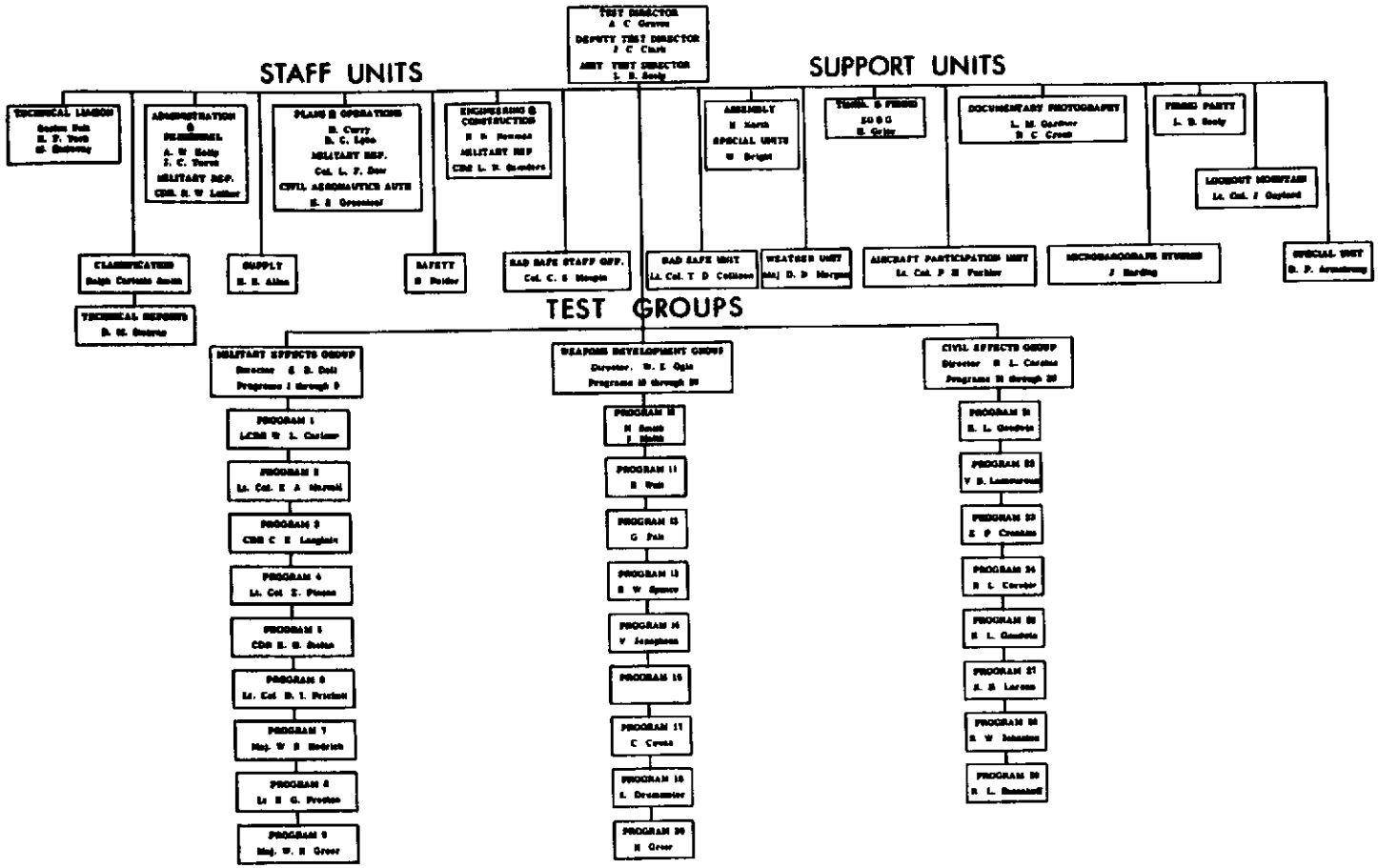


Fig. 8.1 — Test Director's organization chart.

ORGANIZATIONAL CHART
NEVADA PROVING GROUNDS OPERATIONAL PHASE

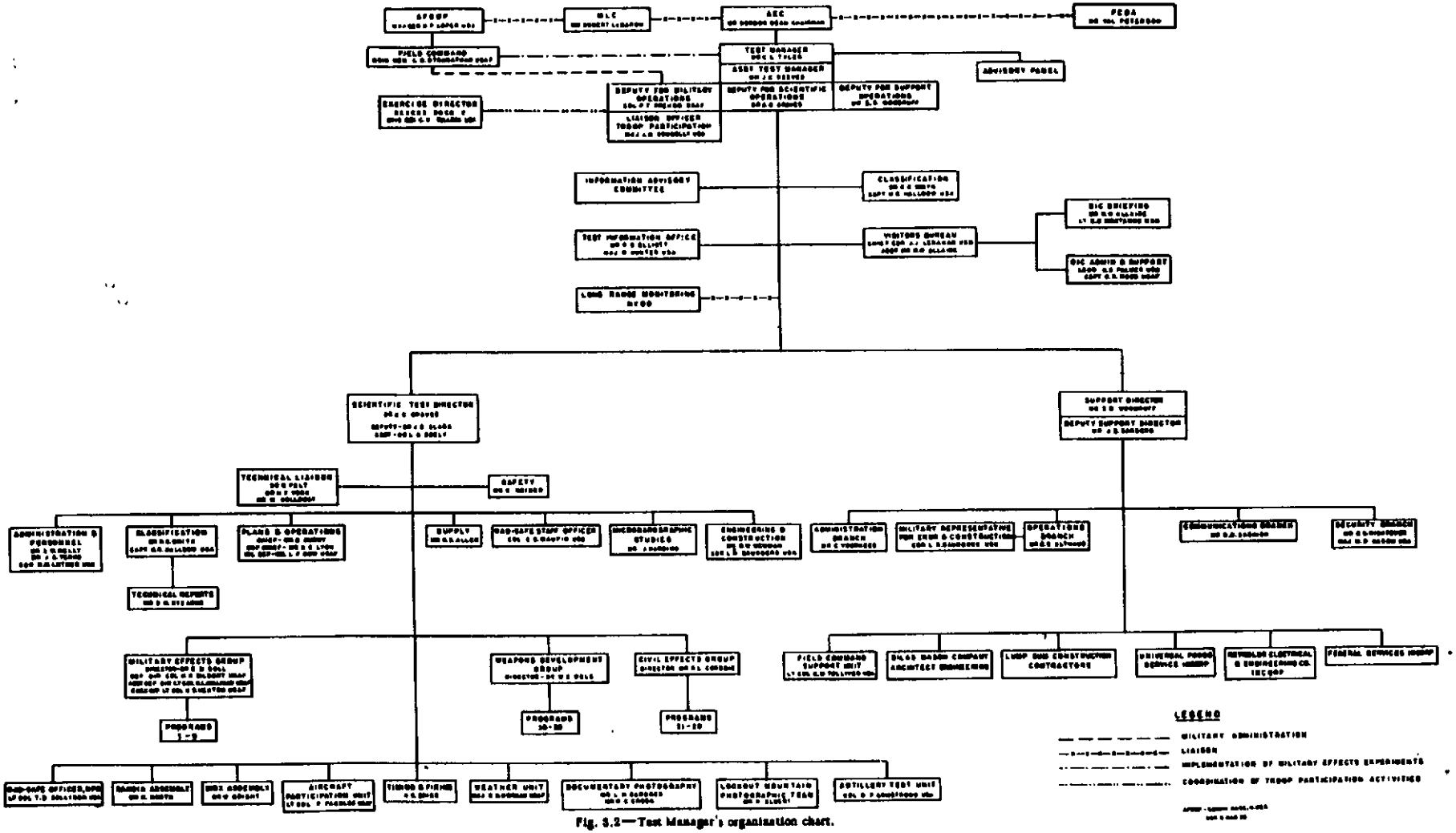


Fig. 3.2—Test Manager's organization chart.

Test Director had a Safety Advisor. It was the Safety Advisor's responsibility to watch the activities of test personnel, as well as to participate in the testing of tower-elevator equipment, and to assure the Test Director that proper safety procedures were being followed. He also acted as liaison on safety matters between the Test Director's organization and the Field Manager's safety office.

3.4 RAD-SAFE STAFF OFFICER

The Radiological Safety (Rad-Safe) Staff Officer advises the Test Director on matters pertaining to the Rad-Safe Unit and assists in the establishment of policy regarding radiological safety problems in general. This officer is preferably a medical doctor with radiological safety training and experience.

3.5 RAD-SAFE UNIT

This is the operating Rad-Safe Unit. The responsibilities of this unit include all Rad-Safe functions within the test area and outside the proving grounds to a distance of approximately 200 miles. Beyond 200 miles the test organization arranges, through DMA, for the New York Operations Office (NYOO) of the AEC to make fall-out measurements and report the results to the Test Manager for whatever action may be necessary in the event of the development of hazardous conditions. Details of the country-wide NYOO operations are given in detail in the AEC semi-annual report for 1952.

For Upshot-Knothole the Rad-Safe Unit was a military organization headed by a military officer. The majority of the military personnel were assigned to the operation from the Chemical Corps Training Command. In addition, the military organization was supplemented with a total of 30 selected persons from the U. S. Public Health Service and 2 persons from LASL (H-Division). This latter group of civilians, assisted by military personnel, constituted the off-site Rad-Safe section of the Rad-Safe Unit.

A complete report of the Rad-Safe Unit is contained in a separate report of this series.

Figures 3.3 to 3.10 show the Rad-Safe instrument calibration setup and some of the off-site Rad-Safe portable equipment at various locations about the proving grounds.

3.6 WEATHER UNIT

As in past operations in Nevada the weather services required by the test organization were supplied by the Air Weather Service of the USAF. A selected group of approximately 68 persons was assembled for the operation, some of whom were detailed in teams to collect weather data at the outlying stations at distances of from 50 to 200 miles outside the target area. The weather center was located in the control building, and it was here that weather data were coordinated from all over the world and prepared for use by the test organization. The Weather Officer presented the weather briefings at the meetings of the Test Manager's Advisory Panel.

A complete report of the Weather Unit is contained in a separate report of this series, WT-703.

S[redacted]



Fig. 3.3—Rad-Safe instrument calibration rack. The rack was located near the Rad-Safe building, control point area.

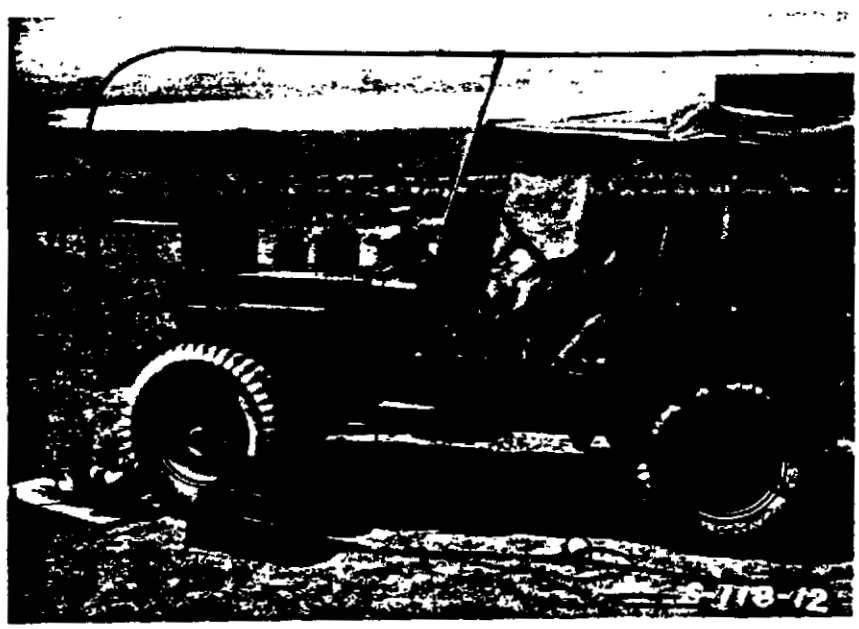


Fig. 3.4—Off-site Rad-Safe jeep. Note high-frequency antenna and other instruments and tools.

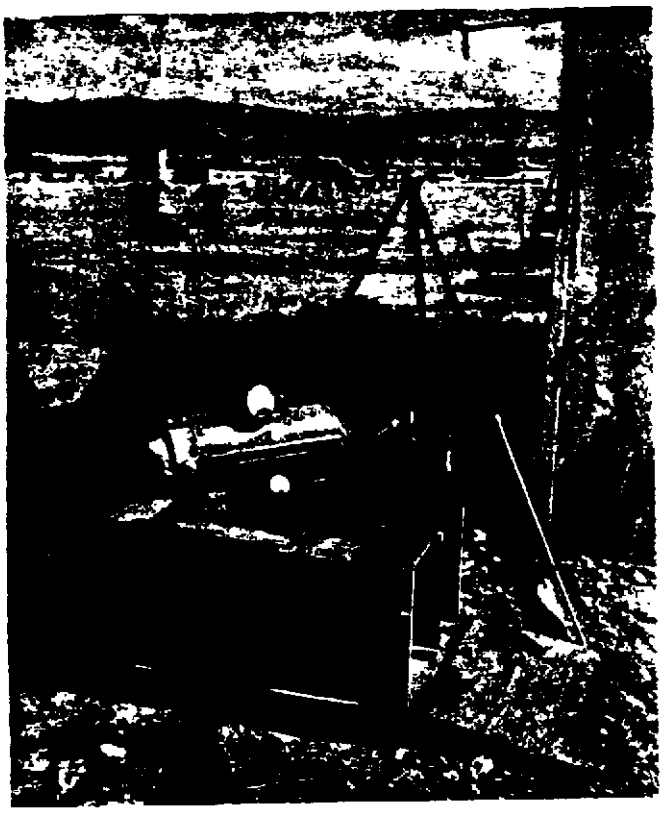


Fig. 3.5—Off-site Rad-Safe setup, Indian Springs, Nev.



Fig. 3.6—Off-site Rad-Safe setup, Nellis AFB, Las Vegas, Nev.



Fig. 3.7—Off-site Rad-Safe setup, Beatty, Nev.



Fig. 3.8—Off-site Rad-Safe setup, Pioche, Nev.

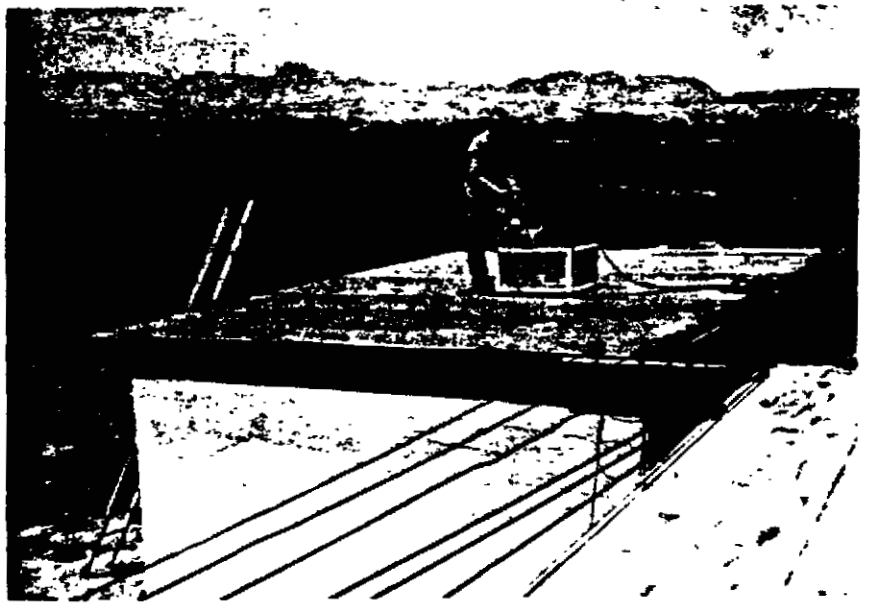


Fig. 3.9—Off-site Rad-Safe setup, Glendale, Nev.

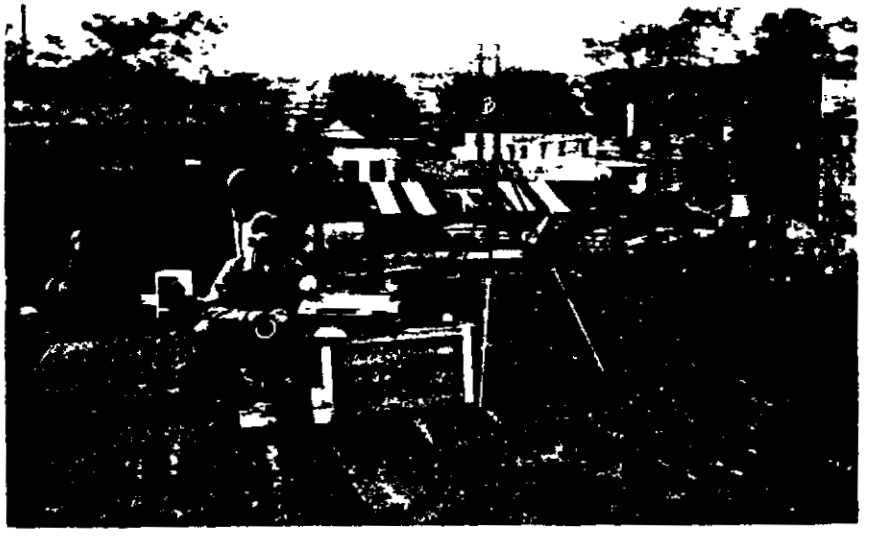


Fig. 3.10—Off-site Rad-Safe setup, St. George, Utah.

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CHAPTER 4

FIRING SCHEDULE AND TEST PARTICIPATION

4.1 FIRING SCHEDULE

The proposed firing schedule as submitted on Dec. 18, 1952, by the Test Director to the Test Manager for AEC approval is given in Chap. 1, Table 1.2. The actual firing schedule, following the reasons set forth in Sec. 2.1 and in Chap. 5 of this report, is shown in Table 4.1. Figure 4.1 shows the Yucca Flat target layout with the actual detonation areas indicated.

Table 4.1—ACTUAL FIRING SCHEDULE, OPERATION UPSHOT-KNOTHOLE

Code name	Description	Firing Date	Firing Time*	Burst height, ft	Type of shot	NPG area
Annie	[redacted]	3/17	−½ hr	300	Tower	3
Nancy		3/24	−½ hr	300	Tower	4
Ruth		3/31	−½ hr	300	Tower	7-5a
Dixie		4/6	0730 PST	6022	Air	7-3
Ray		4/11	−½ hr	100	Tower	4a
Badger		4/18	−½ hr	300	Tower	2
Simon		4/25	−½ hr	300	Tower	1
Dry Run		5/4	0830 PDT			F
Encore	Effects	5/8	0830 PDT	2423	Air	F
Harry	[redacted]	5/19	−½ hr	300	Tower	3a
Grable	Gun	5/25	0830 PDT	524	Air	F
Climax	[redacted]	6/4	−1¼ hr	1334	Air	7-3

* Times measured from sunrise. Actual detonation times are given in Chap. 5.

4.2 TEST PARTICIPATION

As early as feasible in the planning phase of a continental test operation, the Test Director formulates in detail the participation of the various projects in the test program. A participation chart is then prepared, and it becomes a part of the Test Director's operations plan, which is submitted to the Test Manager for final AEC approval. For Upshot-Knothole the Test Director submitted the operations plan on Dec. 18, 1952, and it was approved soon afterward. It is,

[redacted]

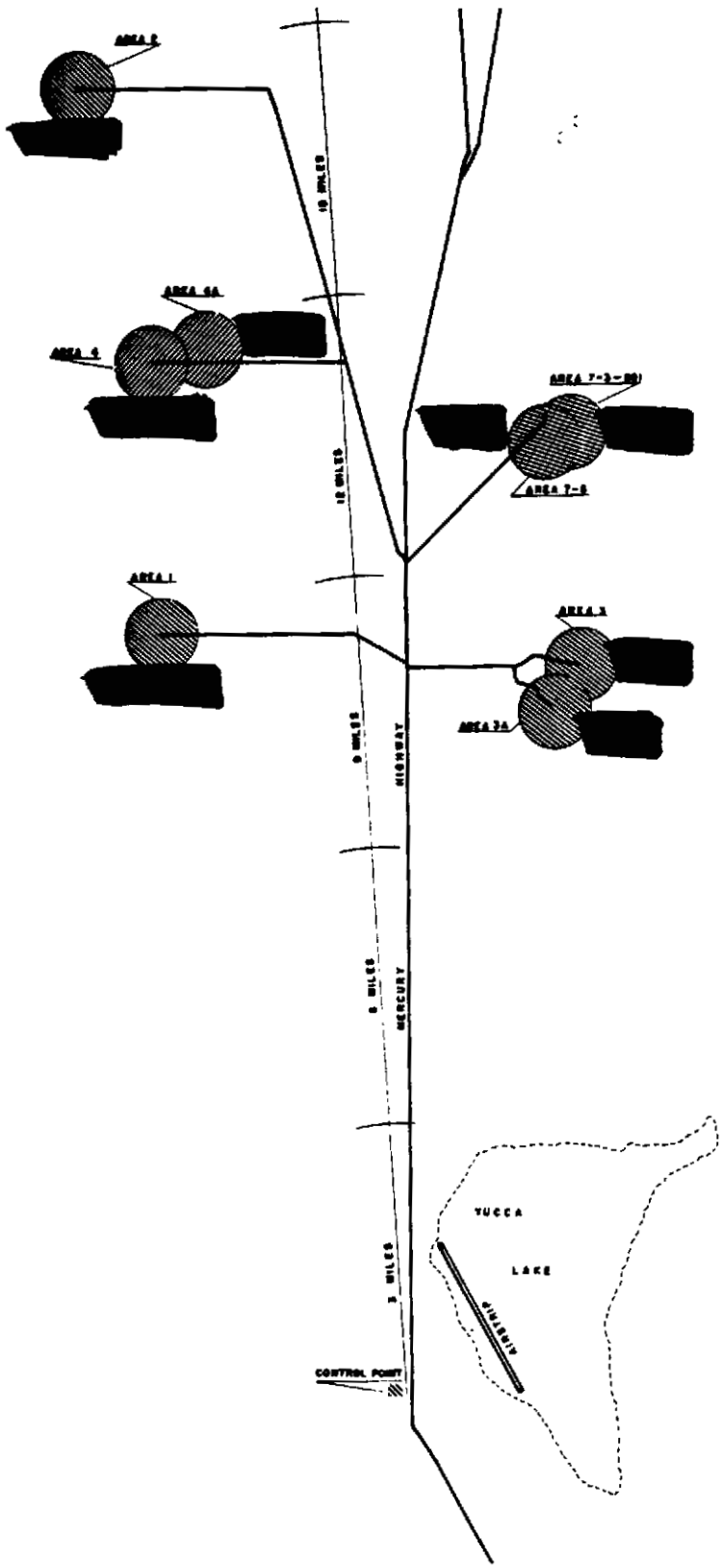


Fig. 4.1—Yucca Flat targets, showing Upshot-Knothole detonations.

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Table 4.2 — ACTUAL TROOP PARTICIPATION, EXERCISE DESERT ROCK V*†

Date	Troop position, dir/yd from GZ	Army	Navy	Air Force	Marine	Civilian	Totals
3/17	SW/3500	303 (O) 1,181 (T)	152 (O)	41 (O)	9 (O)	30 (O)	535 (O) 1,181 (T)
3/24‡	SW/4000	312 (O) 2,349 (75)(T)	90 (O)	80 (O)	17 (O)	16 (5)(O)	515 (5)(O) 2,349 (75)(T)
3/31§							
4/6	News Nob	60 (5)(O)			75 (O)		135 (5)(O)
4/11	News Nob	33 (15)(O)	1 (O)	4 (O)	25 (20)(O)		63 (35)(O)
4/18¶	SW/4000	268 (60)(O)	122 (O)	101 (O)	112 (O) 2,084 (15)(T)	10 (O)	611 (60)(O) 2,084 (15)(T)
4/25**	S/4000	205 (O) 2,450 (65)(T)	14 (O)	340 (O)	1 (O)	24 (2)(O)	584 (2)(O) 2,450 (65)(T)
5/8	SW/9800	315 (O) 2,149 (60)(T)	92 (O)	439 (O)	12 (O)	21 (2)(O)	879 (2)(O) 2,149 (60)(T)
5/19	SW/4000	99 (O) 526 (50)(T)	14 (O)	255 (O)	2 (O)	7 (O)	377 (O) 526 (50)(T)
5/25	E/5000	446 (O) 2,670 (85)(T)	70 (O)	13 (O)	29 (O)	31 (2)(O)	589 (2)(O) 2,670 (85)(T)
6/4§							
Totals		2,039 (80)(O) 11,325 (335)(T)	555 (O)	1,273 (O)	282 (20)(O) 2,084 (15)(T)	139 (11)(O)	4,288 (111)(O) 13,409 (350)(T)
Grand total		13,364 (415)	555	1,273	2,366 (35)	139 (11)	17,697 (461)

* Figures in parentheses indicate "repeat" observers and troops.

† The letters O and T in parentheses indicate observers or troops.

‡ Officer volunteer program: Army, 4; Navy, 4; Air Force, 1. These were located at 2500 yd on 200° azimuth from Ground Zero.

§ No troop participation.

¶ Officer volunteer program: Army, 6; Marines, 6. These were located at 2000 yd on 195° azimuth from Ground Zero.

** Officer volunteer program: Army, 7; Navy, 1. These were located at 2000 yd on 180° azimuth from Ground Zero.

of course, not uncommon in these nuclear tests for the firing schedule and the test participation to be changed between the time the Test Director's operations plan has been approved and the actual firing date. Provisions are therefore made for the Test Director to make minor changes to the approved operations plan.

The actual participation of the various test projects for Upshot-Knothole is given in Appendix A of this report.

4.3 DESERT ROCK PARTICIPATION

Although the Desert Rock V exercises were not under the direction of the Test Director, as pointed out in Sec. 2.2.4, considerable coordination between the two organizations was necessary. For the record, Table 4.2 shows the actual troop participation of Desert Rock Exercise V.

CHAPTER 5

TEST OPERATIONS

5.1 OPERATION PLANS

In a test series such as Upshot-Knothole, there are many features common to all the shots. However, in this series there were air bursts from plane launching, an air burst from cannon launching, and tower shots of various kinds. A few of the devices detonated were assembled by standard procedures, but the remainder required special assembly crews and operations. Desert Rock V exercises varied considerably from shot to shot, and last and most important, the magnitude of technical test participation varied greatly from shot to shot. Therefore for each event the Test Director's staff prepared and issued an operations plan enumerating in detail, when appropriate, the day, hour, and minute of each individual operation before and after the detonation. This operations plan was issued to all concerned not later than D−2 day. In addition to this plan, the Test Director required other more specialized operations plans prepared in detail by groups such as the Firing Party, Special Device Assembly, Standard Weapon Assembly, Desert Rock V personnel movements, Air Operations, and Rad-Safe postshot recovery operations.

5.2 PREPARATION FOR A DETONATION

In general, operations preparatory for a detonation on D-day proceeded somewhat as follows (this assumes some of the more standard type devices detonated).

1. Starting on D−4 day and continuing until 0300 on D−1 day, timing-signal dry runs at 1000 and 1500 daily. On D−1 day at 1000, in addition to the signal dry run, all test participants and other personnel using electrical power and radio equipment were required to operate their apparatus. For those shots where an X-unit (or external initiator) was used to detonate the device, a test X-unit was operated on each signal dry run, and the head of the Firing Party observed its operation in the tower cab. The Go-No-Go circuits were likewise tested. The purpose of the signal and power dry runs was to assure the test participants and the Test Director that these circuits were functioning properly.
2. On D−2 day the Test Director's operations plan was issued.
3. On D−2 day at 2000 the Weather Officer gave the Test Director a prognosis of the meteorological conditions for D-day. This was an informal discussion used for planning the operation and for advising certain groups whether or not to proceed with their operations.
4. On D−1 day at 0700 the Weapon Assembly Group moved the device (without nuclear parts) to the tower cab and installed the X-unit or other firing equipment which would be used for the actual detonation.

[redacted]

5. On D−1 day at 0900 the Weather Officer gave the Test Director and his operational staff a prognosis of weather for D-day. On the basis of this meeting (if the weather looked favorable) an "execute order" was issued, officially starting the actual detonation.

6. On D−1 day at 1000 the last timing-signal dry run and final check of firing equipment were made by the head of the Firing Party.

7. During D−1 day after the 0900 execute order, test apparatus and material were emplaced or finally checked by test personnel. Trailers, portable workshops, and other gear were removed from the test area, blockhouses were made secure, and other final preparations were made as enumerated in the Test Director's operations plan.

8. On D−1 day at 1900 the nuclear assembly team carried out its operation. This was done as late as possible yet with benefit of daylight.

9. On D−1 day at 2030 the Test Manager held the principal weather briefing and Advisory Panel meeting. This meeting was conducted by the Test Director for the Test Manager, and, on the basis of the discussion at this meeting, the decision was made by the Test Manager to proceed with (or delay) the detonation.

10. On D−1 day at 2200 a personnel control check list was put into effect for anyone entering the target area.

11. At approximately D−3½ hr the Firing Party carried out its operations according to its detailed operational check list, finishing at D−2 hr. Also during this period a final security sweep of the target area was made by the security force, and the Security Officer advised the Test Director that the area was clear.

12. At D−2 hr a HE charge of approximately 2400 lb of TNT was detonated somewhere in the target area. This shot was made for the microbarographic group, which, after about 30 min following this detonation, furnished the Test Director with data on off-site blast and a prediction of what might occur from the nuclear shot. If the Test Manager considered it desirable, the Public Relations Officer alerted any population center where abnormal blast might result.

13. At D−1 hr the second HE charge for the microbarographic group was detonated. This second shot provided a more reliable prediction of the off-site blast which might result from the nuclear shot.

14. From D−1 hr until zero the time signals were sent out as planned, air operations proceeded as prescribed by the air operations plan, and preparations went ahead for postshot recovery operations.

15. As soon after the nuclear detonation as possible, the Test Director, on the advice of the Rad-Safe Staff Officer, declared recovery hour (R-hour), and at that time recovery operations proceeded as prescribed. Likewise cloud sampling, cloud tracking, Desert Rock exercises, etc., all went ahead as planned.

16. As soon as possible after the shot, generally about 10 hr, the Test Director dispatched a teletype to the laboratory directors concerned, the DMA-AEC, and SFOO, giving preliminary results of the test and other pertinent incidents which occurred.

The above procedures applied to a tower shot. For an air burst the same general plan was followed, modified in two main aspects, namely, the weapon assembly and movement operations were carried out at the air base for the drop airplane, and the preshot air operations were more elaborate and came under the direct supervision of the Test Director as soon as the drop airplane entered the test area.

5.3 DETAILS OF THE ELEVEN NUCLEAR DETONATIONS

5.3.1 [redacted] See Sec. 2.1.1)

(a) General Preparations. Coaxial lines from the tower cab to the control blockhouse 2000 ft away were installed and tested during the period from D−3 to D−1 week[redacted] On the morning of D−3 day [redacted] unit without nuclear parts was installed, and the tower-cab side wall in the direction of the high-speed camera station was removed. Removal of this face presented a small security problem because on D−2 day

[redacted]

the uncleared press and FCDA visitor groups were taken into the target area to look at the FCDA houses, automobile display, and FCDA and AEC protective shelters. On the evening of D−1 day, the nuclear insertion was made by representatives of Group W-1, LASL. Figure 5.1 shows the [redacted] installation in the tower cab of Area 3 prior to detonation.

(b) Meteorology. At the 2100 weather briefing and Advisory Panel meeting on D−1 day, the weather forecast was as shown in Table 5.1 with predictions for no precipitation within 500 miles downwind and $^{4}/_{10}$ cirrus at 30,000 ft. Since this forecast indicated the cloud would pass near Lincoln and Groom Mines, provision was made to warn and evacuate, if necessary, personnel at these locations. However, as shown in the table, the winds changed and the 0100 wind readings on D-day prevailed at shot time. Figure 5.2 shows one of the outlying weather stations used for providing data for the weather forecast.

Table 5.1—WINDS ALOFT [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0100 PST, D-day		Actual winds at shot time, D-day		Actual winds at 0700 PST, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	200	04					Calm	
6,000	200	15	210	09	290	08	360	07
8,000	220	15	200	16	280	06	330	10
10,000	230	18	260	13	270	25	270	12
12,000	230	20	270	20	270	25	260	15
14,000	230	20	270	40	270	21	280	20
16,000	240	25	270	32	270	34	280	20
18,000	240	27	270	38	270	42	280	42
20,000	240	30	270	45	270	54	270	42
25,000	230	35	270	49	270	47	270	60
30,000	230	40	270	65	270	68	260	60
35,000	240	45	270	46	260	53	260	71
40,000	240	50	250	63	260	89	260	93

* These data used by the Weather Officer during the 2100 PST Advisory Panel meeting.

(c) Detonation. The [redacted] was detonated at 0520:00.328 ± 0.002 sec PST, 17 March 1953, on a 300-ft 30-ton three-legged steel tower, in Area 3, Yucca Flat.

Actual cloud cover	$^{7}/_{10}$ cirro-stratus
Weather-cloud height	30,000 ft MSL
Nuclear-cloud height	40,000 to 42,000 ft MSL

Two 2400-lb TNT detonations for microbarographic data preceded the nuclear detonation, one at D−2 hr and the other at D−1 hr. Both these shots indicated there might be a heavy shock at Indian Springs. However, no damage or nuisance resulted from the off-site blast effects. A late photo of the [redacted] detonation is shown in Fig. 5.3.

(d) Results. Individual reports covering all experiments are a part of the series of reports of Operation Upshot-Knothole, and reference to these reports should be made for the final results of the projects participating. Some of the data require several months for final analysis, and, for this reason, only general statements of results will be made in this report.

Programs 1 to 9. In general, the projects which were carried out in the military effects programs showed successful results. The most important aspects of these tests were the blast measurements made both in free air by the rocket-trail technique and along the ground by standard blast gages. These data, when correlated with similar data taken during Operation

[redacted]

[redacted]

Fig. 5.1—[redacted]



Fig. 5.2—Permanent off-site weather station, Crystal Springs, Nev.

[redacted]



Fig. 5.3—Late photograph o[redacted]etonation.

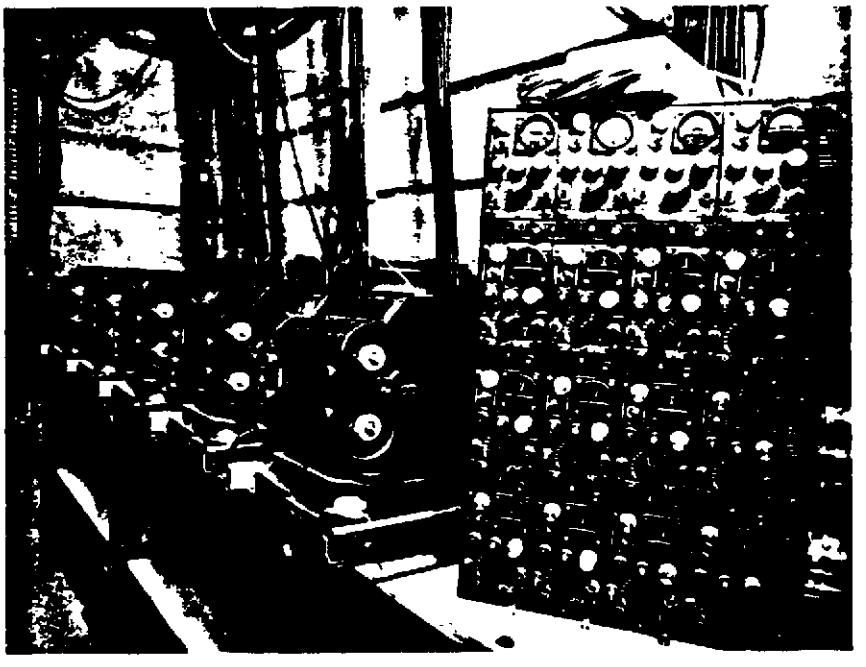


Fig. 5.4—Project 24.3 recorders in Station 610, Area 3.

[redacted]

Greenhouse, showed marked differences, particularly in the surface data, indicating that the precursor does not form over water. Program 6 experienced some difficulty with cameras and scopes not functioning satisfactorily, but no important data were lost. Radio interference also caused some trouble. In Project 5.1 the drone aircraft, not scheduled to participate on this shot, were operated with safety pilots to check on the operational procedure and observe the functioning of the remote-control equipment. This test proved valuable from several standpoints and undoubtedly contributed much to the successful drone participation in later tests.

Programs 10 to 20. [redacted]

Programs 21 to 29. As may be seen from the project participation chart (Appendix A), all programs between 21 and 29 except 22 and 27 conducted experiments on this shot. All projects were ready by shot time, although considerable overtime work was necessary for the instrumentation group making measurements on the AEC shelters in Program 24. This was due primarily to delays in completion of contractual arrangements with the instrumentation group. However, the work was completed, all circuits were tested a few hours before shot time, and good results were obtained. Dogs, mice, and other genetic materials were used in the tests for Program 23, and all animals were satisfactorily recovered after the detonation. The FCDA "backyard" shelters and the much publicized two FCDA wooden-frame houses were exposed on this shot. The nearer house (3500 ft) was completely demolished, and the farther one (7500 ft) was structurally damaged and considered uninhabitable.

Figure 5.4 shows recorders of Project 24.3 in Station 610, Area 3. These recorders were used to measure pressures, accelerations, and displacements in the AEC communal shelters. Figure 5.5 shows the interior of one of the AEC communal shelters, Area 3, with a dummy placed near the middle of the shelter. High-speed motion pictures were made of the motion of the dummy, and accelerometers were placed inside the dummy for measuring the forces acting upon it during the blast period. Figure 5.6 shows vertical and horizontal accelerometer gages mounted in Station 601, Area 3, the AEC communal shelter.

Figures 5.7 to 5.10 were taken from a film made of the FCDA frame dwelling at 3500 ft from zero on the [redacted]hot just prior to and during the time the blast wave struck the house. Figure 5.7 was taken at the instant of detonation, before the blast wave arrived. Figure 5.8 was also taken before the blast wave arrived and shows the charring and burning of surfaces exposed to the intense thermal radiation from the detonation. Figures 5.9 and 5.10 show the blast-wave action. Figure 5.11 is a still photograph made of the 3500-ft FCDA frame house after the detonation.

Figure 5.12 is an interior view of one of the AEC communal shelters instrumented with animal cages used in the biomedical studies done as part of Programs 23 and 24. Figures 5.13 and 5.14 show mannequins arranged in one of the rooms of the FCDA frame houses at 7500 ft from zero, Area 3, before and after the [redacted] detonation.

(e) On- and Off-site Fall-out. The details of the Rad-Safe operations are contained in a separate report in the Upshot-Knothole report series. The initial radiological survey of the target area, made 1 hr after the detonation, is shown in Fig. 5.15. Subsequent surveys made on successive days are given in the Rad-Safe report. Off-site fall-out from the [redacted] detonation is shown in Fig. 5.16. It should be pointed out that the isodose lines shown in the off-site fall-

(Text continues on page 49.)

[redacted]

[redacted]

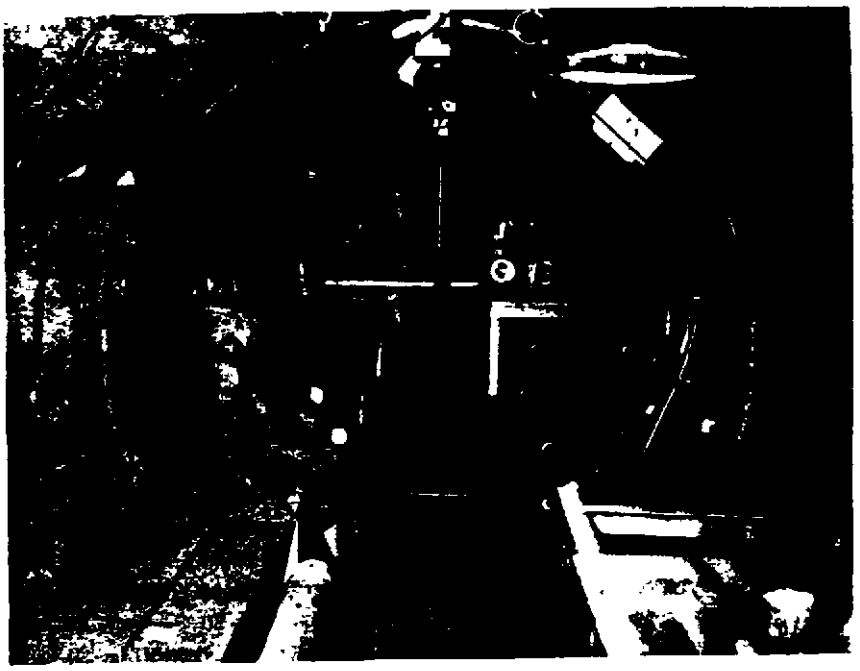


Fig. 5.5—Interior of AEC communal shelter, Area 3.

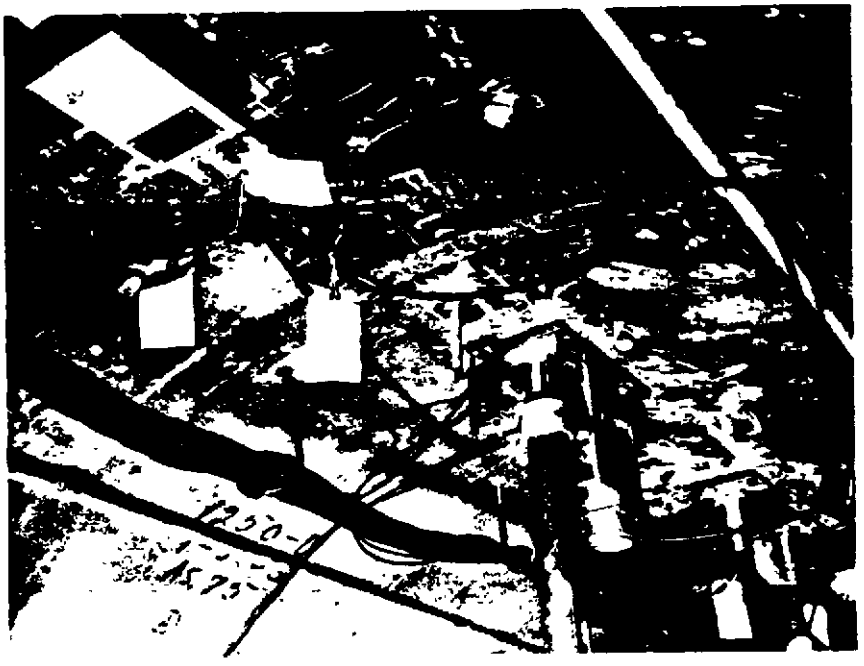


Fig. 5.6—Miscellaneous gages mounted on AEC shelter, Station 601, Area 3 (Project 24.3).

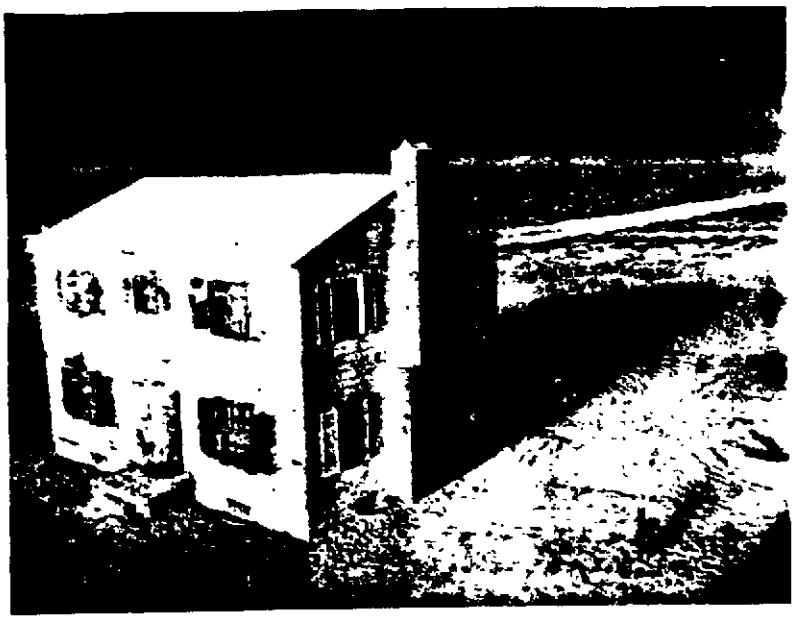


Fig. 5.7—FCDA house 3500 ft from zero at instant of detonation.

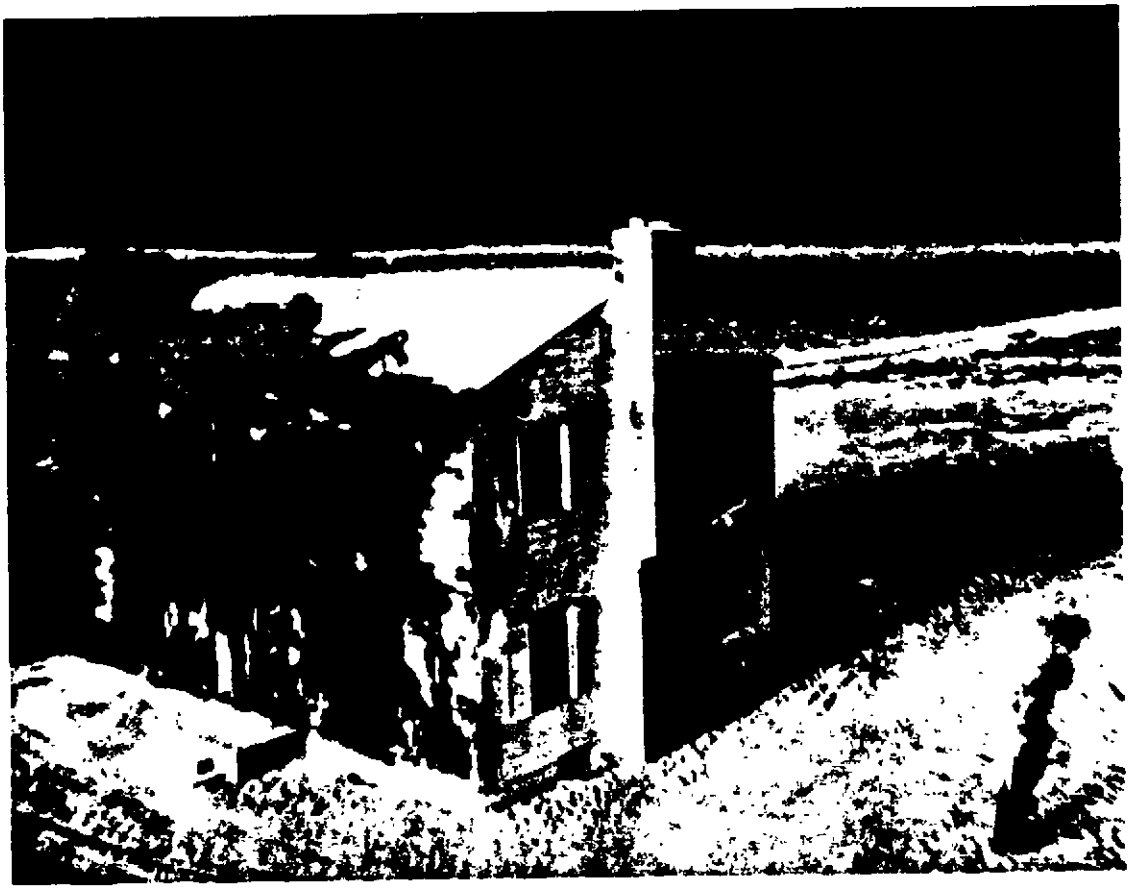


Fig. 5.8—FCDA house just before blast wave arrived.



Fig. 5.9—FCDA house, showing blast-wave action.

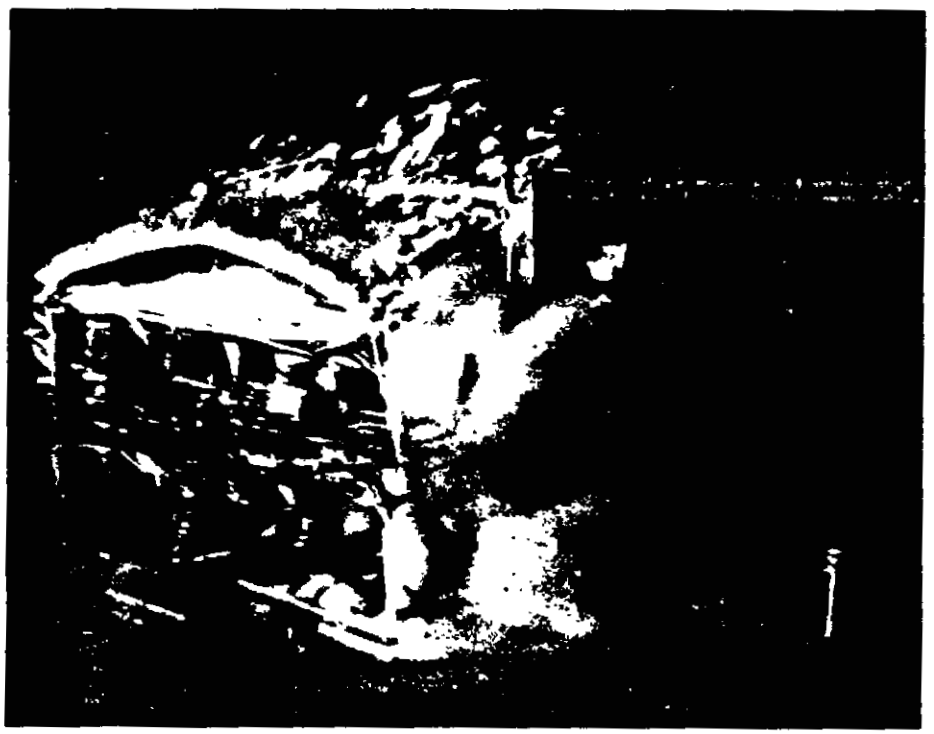


Fig. 5.10—FCDA house, showing blast-wave action.



Fig. 5.11—FCDA house after the [redacted]hot, Area 3.



Fig. 5.12—Interior of AEC shelter, showing animal cages.

[redacted]

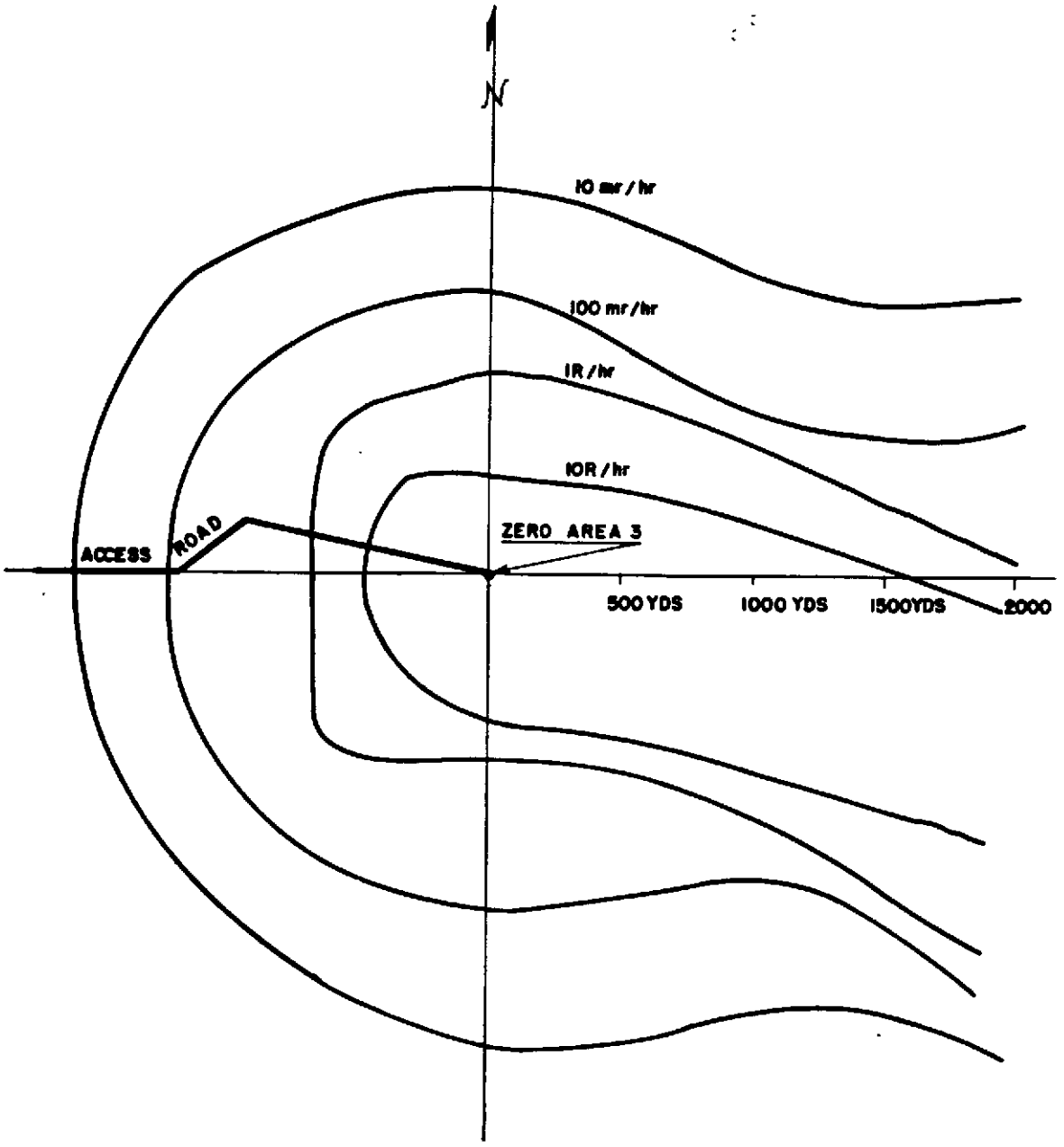


Fig. 5.13—Mannequins in FCDA house 7500 ft from zero, before [redacted] detonation.



Fig. 5.14—Mannequins in FCDA house 7500 ft from zero, afte[redacted] etonation.

[redacted]



DETONATION TIME 0520 PST 17 MARCH 53
SURVEY TIME 0630 PST 17 MARCH 53

Fig. 5.15—Radiological situation, Area 3, Yucca Flat [redacted] shot.

[redacted]

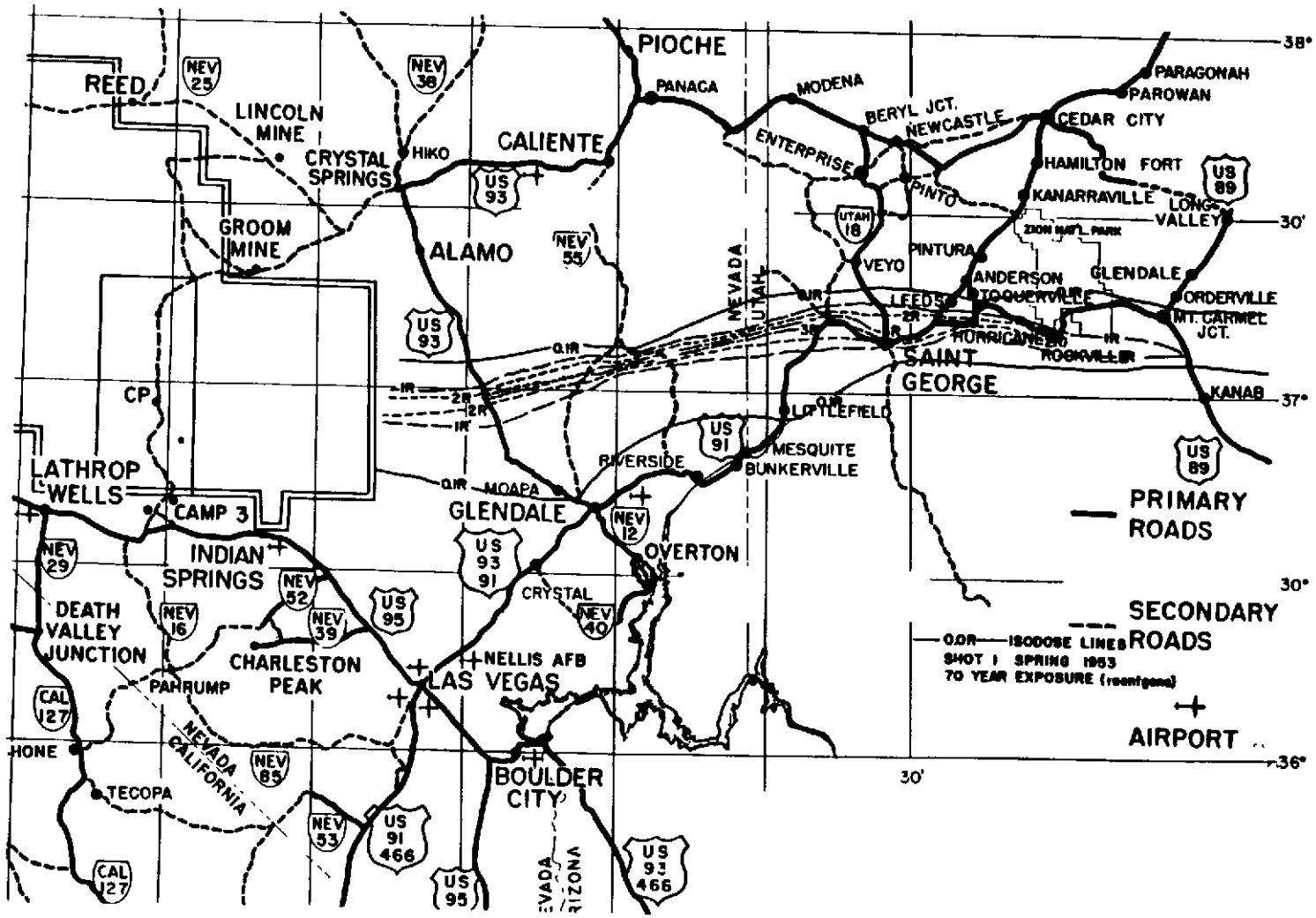


Fig. 5.16—Off-site fall-out from [redacted] detonation.

out plot are lifetime doses based on the $t^{-1.1}$ decay relation, allowing for no weathering or other decontaminating processes. A person spending much time inside buildings would not receive the full dose shown on the plot.

(f) Other Details of the Shot. Observers. The AEC decided that a group of uncleared people of the press and prominent officials invited by the FCDA should be permitted to observe the FCDA installations and the detonation. On March 15 these people were taken on a conducted tour of Area 3 for the purpose of examining FCDA automobiles, underground shelters, and the house installations. During shot time these people were located on News Nob near the Control Building, and from there the shot was televised for nationwide programs. The plan was to have a conducted tour of the two FCDA houses after the detonation, but, because of the excessive ground contamination in that area resulting from the detonation, the Test Manager considered this unwise. Instead these observers were taken as far as the 100-mr line at D+5 hr, where they observed the damage from their buses.

Official observers from the AEC, DOD, LASL, UCRL, and Sandia Corporation were located in the observer area 1000 ft north of the Control Building.

Desert Rock V Exercises. A full dress rehearsal was held for two composite Battalion Combat Teams on Mar. 14, 1953. On shot day there were 1181 troops and 535 observers located in trenches at 3500 yd approximately south of Ground Zero. The troops started their postshot exercises at 0535 PST. No unusual radiological or blast problems existed, but, to keep within the Rad-Safe criteria, the troops and observers were halted 700 yd from Ground Zero. As part of the maneuver a Marine helicopter detachment stationed at Camp Desert Rock airlifted 16 troops in four type HRS-2 helicopters from the trench area to the 2500-yd line during the exercises after the shot. Since this was an "open shot," a few newsmen and radio personnel were present in the trenches during the shot. Typical military items were exposed for troop indoctrination in an area from Ground Zero to 3500 yd from zero. No animals were displayed on this shot. Damage to equipment was slight beyond 1000 yd from zero.

5.3.2 [redacted] (See Sec. 2.1.2)

(a) General Preparations. The responsibility for the complete assembly of the device in the tower cab was with the LASL DIRX group. [redacted] Figure 5.18 shows the [redacted] device installed in the tower cab, Area 4.

(b) Meteorology. The wind structure predicted for shot time and presented by the Weather Officer during the Advisory Panel meeting at 2100 on D−1 is given in Table 5.2. The forecast was no precipitation downstream within 500 miles, and $\frac{1}{10}$ to $\frac{2}{10}$ cirrus above 30,000 ft, with a nuclear-cloud height of 43,000 ft. Everett Cox predicted no blast damage would result, although Caliente was in a "noisy" region. Fall-out was predicted in the general region of Hiko, Caliente, and Pioche, and this situation was not considered ideal. However, the Weather Officer was of the opinion that the wind structure would not change appreciably in 48 hr and that any change would probably be for a more southerly downwind pattern, which was considered even less favorable. The decision was made to continue with the shot but to watch the winds throughout the night and have firm plans for controlling populated areas if it became necessary.

(c) Detonation. The [redacted] was detonated at 0510:00.086 ± 0.001 sec PST, 24 March 1953, on a 300-ft 100-ton four-legged steel tower in Area 4, Yucca Flat.

Actual cloud cover	Clear
Nuclear-cloud height	41,000 ft MSL

[redacted]



Fig. 5.17—300-ft 100-ton steel tower in Area 4. [redacted]

[redacted]

Fig. 5.18—[redacted] device in tower cab, Area 4.

[redacted]

Two 2400-lb TNT charges were detonated for the microbarographic group at −2 and −1 hr. Both these detonations indicated that Caliente would get a shock but that it would not be of damaging magnitude.

(d) Results. Detailed results covering all experiments performed by the projects participating in this shot are contained in separate reports forming part of the Upshot-Knothole report series.

Table 5.2—WINDS ALOFT [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0100 PST, D-day		Actual winds at shot time, D-day		Actual winds at 1000 PST, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	330	03					Calm	
6,000	190	03	130	05	210	16	160	11
8,000	200	15	150	10	150	18	180	14
10,000	210	20	150	10	150	12	190	15
12,000			190	12	170	09	190	18
14,000			210	06	200	18	180	21
16,000	210	25	240	08	210	16	190	27
18,000			250	11	190	11	200	25
20,000	220	30	240	14	210	20	220	30
25,000	230	40	210	18	210	25	240	32
30,000	240	50	220	17	220	31	220	40
35,000	250	50	220	32	210	27	230	37
40,000	260	40	240	28	220	32	230	42

*These data used by the Weather Officer during the 2100 PST Advisory Panel meeting.

Programs 1 to 9. The military effects participation on this shot was minimal. Of those projects participating, all report successful results except for the malfunctioning of equipment in Project 6.9, which prevented the dropping of cannisters. A total of 130 rabbits was exposed in a flash-blindness test, with 74 out of the 130 receiving retina burns, some as far away as 25 miles from zero.* A Navy drone plane was operated "nolo" for this shot for aircraft-structure tests, this being the first time unmanned drones had been used in continental operations. The drone was successfully controlled throughout the test and was landed safely at the Indian Springs airstrip after the mission.

Programs 10 to 20. [redacted]

*See Report WT-745 for further details.

[redacted]

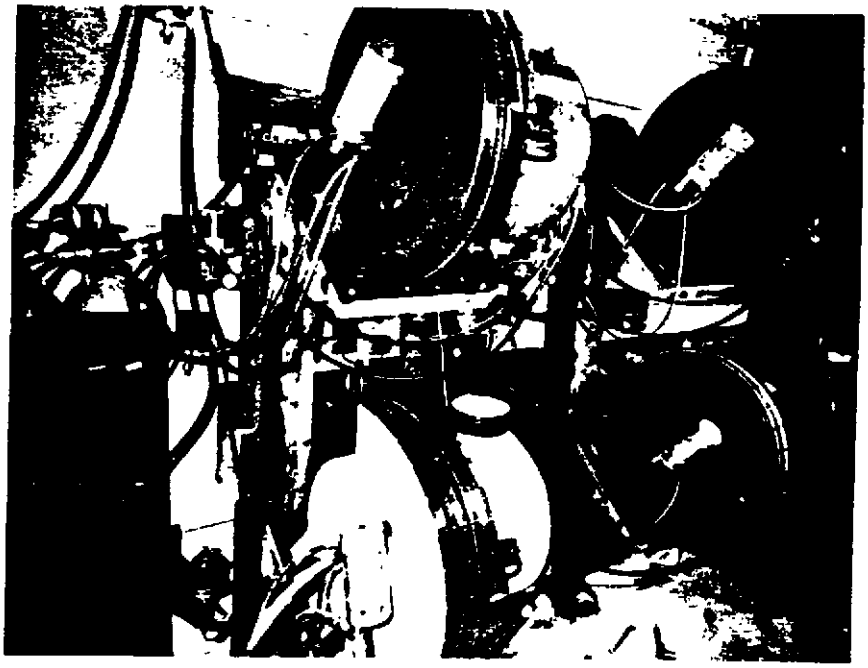


Fig. 5.19—Project 12.2, models 6 and 100 ultra-high-speed cameras in Station 380, Area 4. [redacted]

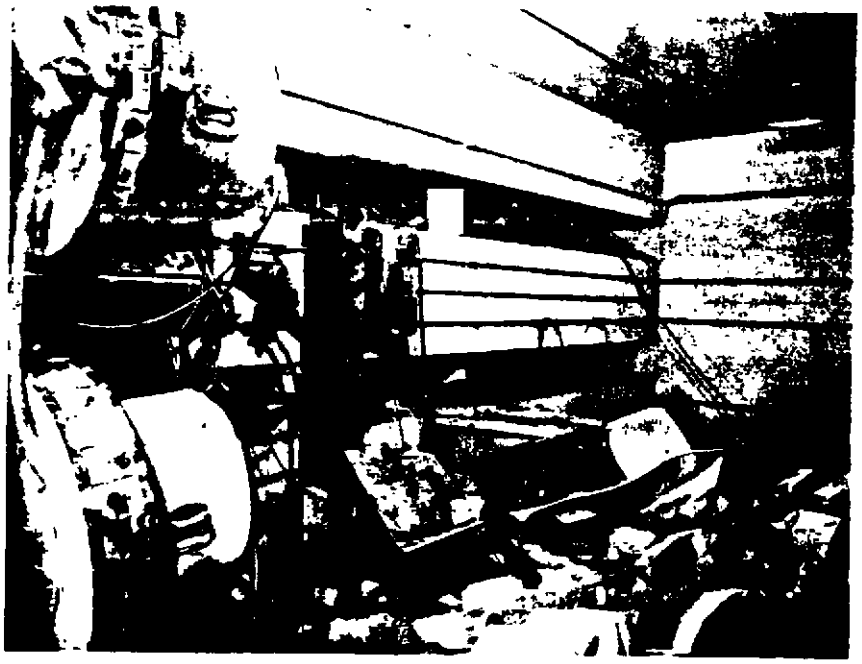


Fig. 5.20—Models 6 and 100 cameras in Station 380, Area 4, after [redacted]hot. Blast doors over optical apertures did not close satisfactorily.

[redacted]

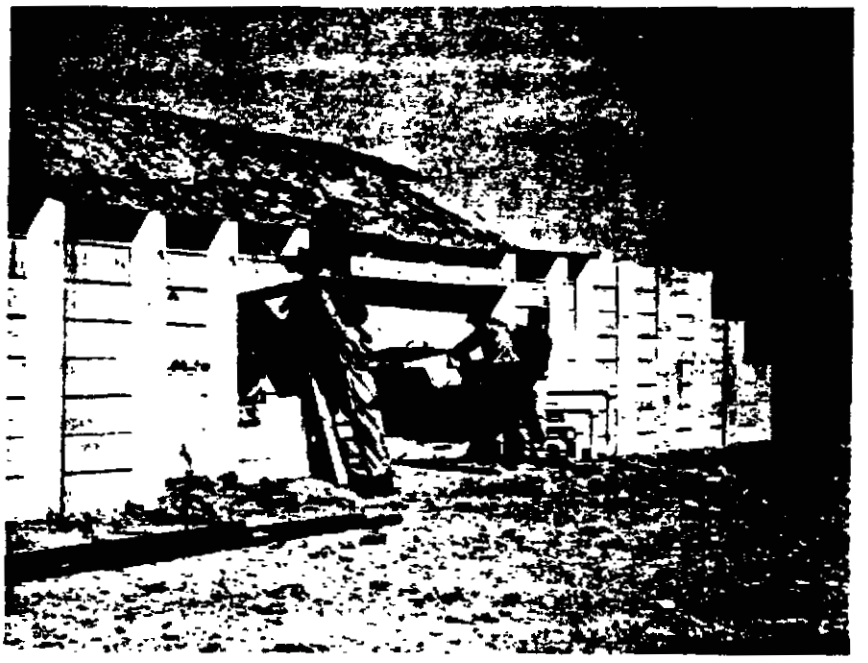


Fig. 5.21—Blast doors on optical apertures at high-speed-camera station, Building 1-380, Project 12.2.



Fig. 5.22—Timing and control gear for ultra-high-speed cameras, Building 4-380, Project 12.2.

[redacted]

Programs 21 to 29. Only Programs 27, 28, and 29 participated on this shot. Considerable radio-communication trouble was experienced between the control point and the off-site stations of Project 27.1. Owing to the mountainous terrain near the proving grounds, VHF communication is not satisfactory, and the present HF equipment at the site is not yet sufficient to handle the wide variety of off-site requirements which occur during these tests. Additional relay stations for VHF are perhaps the solution to the problem.

With the exception of Project 27.1, all projects participating in this shot obtained satisfactory results.

On- and Off-site Fall-out. For the details of the Rad-Safe operations, reference should be made to the Rad-Safe report in the Upshot-Knothole report series.

The on-site ground-contamination plot 1 hr after detonation is shown in Fig. 5.29. It is seen that, although entrance was made into Station 300, 1000 yd east of the target point, it was not possible to gain entrance into the high-speed photostation 500 yd west of zero. Entrance to this station was not made until D+3 day, by which time the area had cooled off enough to get into the station and get the film, but the camera equipment was not removed until D+10 day. It is also seen from this plot that considerable contamination resulted in Area 2. In fact, work on the tower in Area 2 was halted, and, as is pointed out in Sec. 2.1.5, it was necessary to rearrange the schedule for th[redacted]shot as a result of the excessive contamination from the [redacted] shot.

The off-site fall-out plot is shown in Fig. 5.30. It is seen that, with the change in wind directions from those predicted at the 2100 briefing, the fall-out occurred in a more northerly direction. After the 0100 PST wind data on D-day, two off-site monitors were moved to the Lincoln Mine area, and good radio contact was maintained between Lincoln Mine and the Rad-Safe control center in the Control Building. The data in Table 5.3 show the gamma exposure levels at Lincoln Mine as radioed to the control center. Shot time was at 0520 PST, and the first visual evidence of cloud passage over Lincoln Mine was at 0550, with the peak at 0615. However, fall-out did not start until 0650, with the maximum occurring at 0709.

Following the Rad-Safe operation evacuation plan, the Deputy Test Director advised the Rad-Safe officer at Lincoln Mine by radio that personnel there should remain indoors until further notice. The mine superintendent was extremely cooperative, and the order was carried

[redacted]

Page 55 is deleted.



Fig. 5.25—Interior of Program 11 recording station. Located 300 ft from zero [redacted] shot.

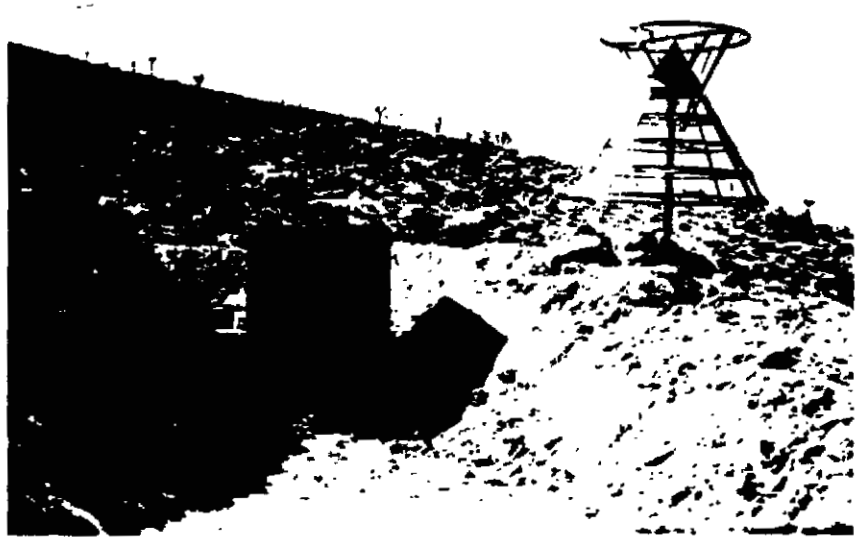
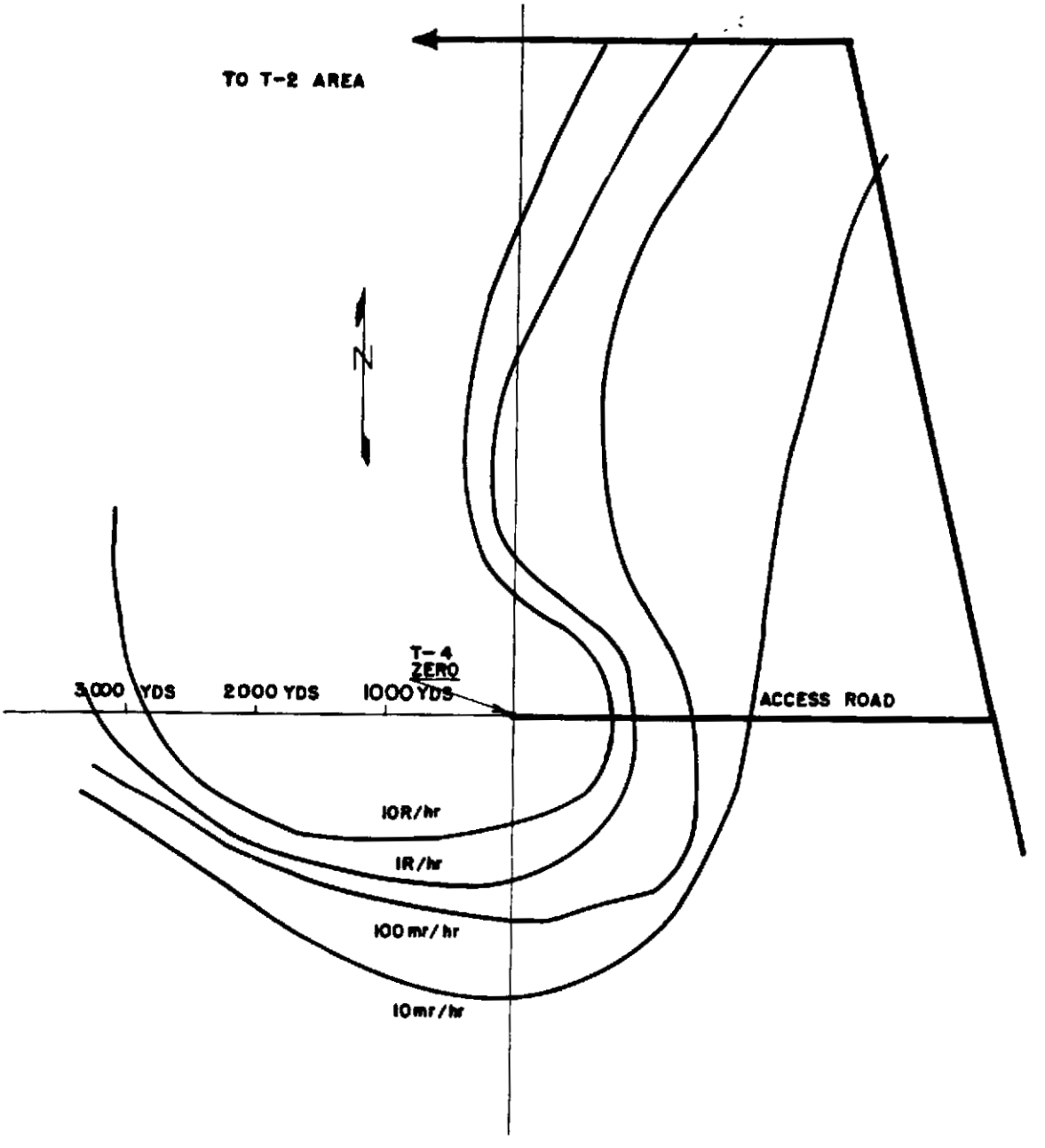


Fig. 5.26—Special antenna used by Project 15.4 for electromagnetic studies.

Pages 57+58 are deleted.

SECRET—RESTRICTED DATA



DETONATION TIME 0520 PST 24 MARCH 53
SURVEY TIME 0610 PST 24 MARCH 53

Fig. 5.29—Radiological situation, Area 4, Yucca Flat, [redacted] shot.

[redacted]

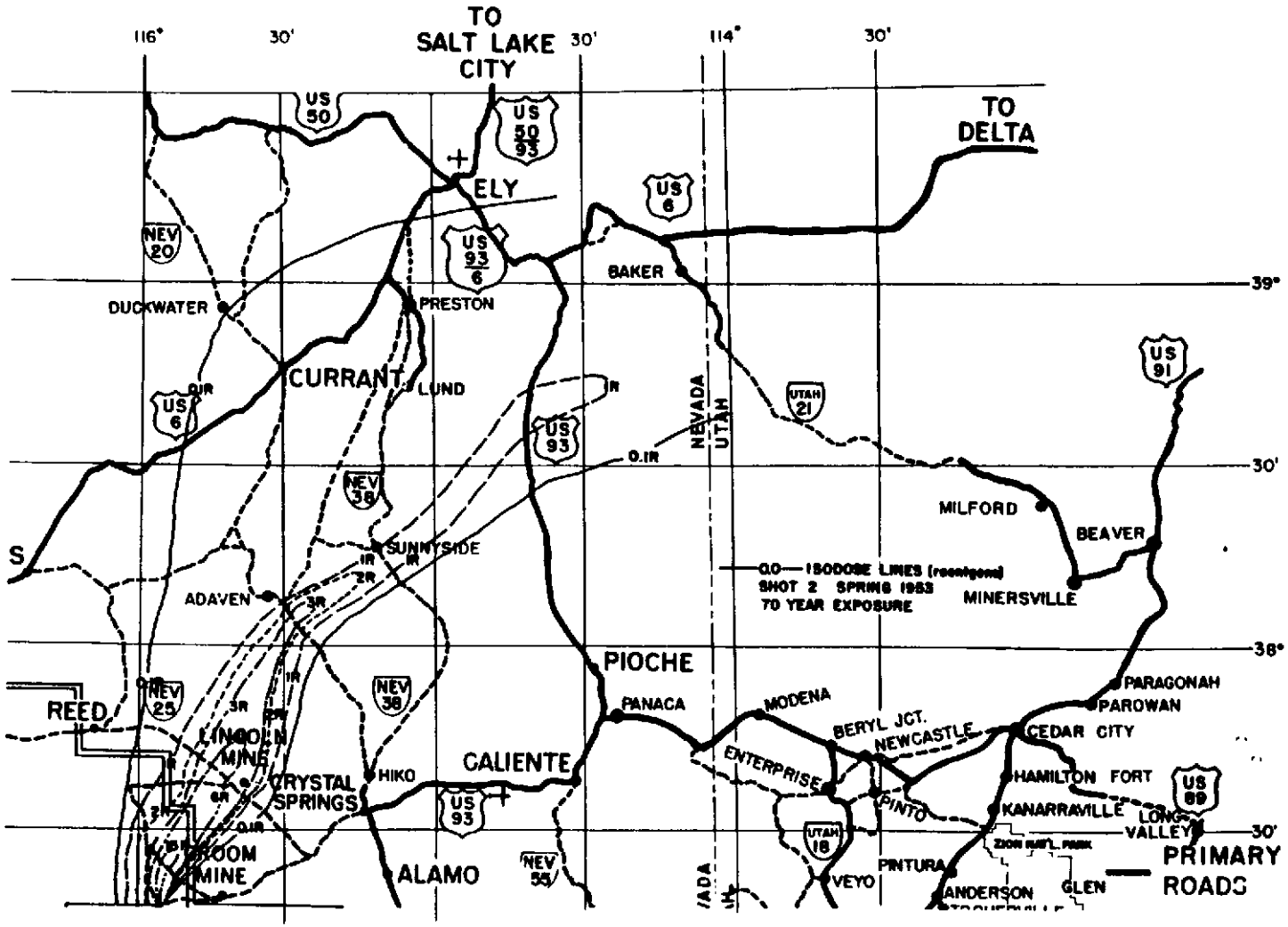


Fig. 5.30—Off-site fall-out from [redacted] detonation.

out. At 0900 the Deputy Test Director again advised the Rad-Safe officer at the mine that the 0700 order was rescinded and that people could resume their normal duties but should remain inside throughout the day as much as possible. On the basis of film-badge and other collected data, personnel at the mine location received less than 3.4 r total lifetime dose. At 0830 the Deputy Field Manager of NPG flew up to the mine area and made a complete survey of the situation.

This was the first time in any continental test that any "nuisance" action was taken by the test organization. The off-site Rad-Safe organization and communications functioned much better for this operation than for previous continental tests, and, as will be seen for later tests, much better control of the off-site Rad-Safe situation was maintained.

Table 5.3—GAMMA EXPOSURE LEVELS AT LINCOLN MINE, SHOT DAY [redacted]

Time	Exposure, mr/hr	Time	Exposure, mr/hr	Time	Exposure, mr/hr
0650	3.2	0709	580	0825	225
0655	28	0711	460	0920	160
0656	150	0714	450	1140	100
0700	350	0730	350	1440	50
0703	500	0750	300	2010	28

(f) Other Details of the Shot. Desert Rock V Exercises. For this shot the Battalion Combat Team consisted of 515 observers and 2349 troops entrenched 4000 yd from zero. In addition, there was an officer volunteer program in which nine officers were entrenched 2500 yd from Ground Zero. None of these officers received more than a 1-r total dose. A display area was arranged between the entrenchment area and Ground Zero as part of the Desert Rock V exercises. Animals (sheep) and military equipment were displayed.

5.3.3 [redacted] (See Sec. 2.1.3)

(a) General Preparations. The estimate of yield for this device varied from time to time during the construction phase of the operation, and, in order to be reasonably sure that the radiological hazards were minimized, it was decided to use a 300-ft tower for the shot. A Ground Zero point was chosen 400 ft south of the zero used for [redacted] Operation Buster, thus making it possible to utilize the coaxial lines which were already installed leading to the alpha control station. [redacted] Final signal and power dry runs were accomplished at 1000 PST on D−1 day, and the nuclear insertion was made by the UCRL nuclear group at 1530 PST on D−1 day. A UCRL representative was a member of the Firing Party on this shot.

(b) Meteorology. At the 2100 weather briefing and Advisory Panel meeting on D−1 day, the wind-pattern forecast for shot time was as shown in Table 5.4, with clear skies and no precipitation downstream within 500 miles. A cold front was moving down from Canada and would reach the northwest tip of Nevada by shot time. Because the ridge accompanying the front would be in the vicinity of the proving grounds at shot time, wind predictions were difficult to make. The most extreme condition which could prevail would be a 290° direction for the 20,000-ft winds. The forecast for the following day was for cloudiness and higher wind velocities. On the basis of the forecast wind pattern and an estimated yield [redacted] the estimated cloud height was 18,000 to 21,500 ft MSL. The maximum fall-out was predicted to be within the 50-mile zone with the cloud moving just north of Las Vegas. However, a small fall-out on Las Vegas could result in a nuisance problem involving both film storage and

[redacted]

public relations. The off-site blast effects were predicted to be of no consequence. The decision was made to have the detonation.

(c) Detonation. The [redacted] was detonated ½ hr before sunrise, at 0459:59.994 ± 0.001 sec PST, 31 March 1953, on a 300-ft 30-ton three-legged steel tower in Area 7-5a, Yucca Flat.

Actual cloud cover	Clear
Nuclear-cloud height	13,000 ft MSL

The 2400-lb TNT charges were detonated for the microbarographic group at −2 and −1 hr, and both these shots indicated that no damaging off-site blast effects would result.

Table 5.4—WINDS ALOFT [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0100 PST, D-day		Actual winds at shot time, D-day		Actual winds at 0600 PST, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	360	04					Calm	
6,000	330	10	310	09	010	12	010	12
8,000	300	15	320	12	350	11	350	11
10,000	270	20	320	19	320	14	310	14
12,000			320	17	310	10	310	16
14,000			320	20	320	25	320	20
15,000	290	25			330	23	330	22
16,000			300	25	330	24	330	23
18,000			290	26	320	30	320	29
20,000	300	30	300	24	320	30	320	31
25,000	300	32	280	29	330	34	330	32

* These data used by the Weather Officer during the 2100 PST Advisory Panel meeting.

(d) Results. Reference should be made to the individual Upshot-Knothole program reports covering the experimental groups that participated.

Programs 1 to 9. The yield of this device turned out to be less than ½ Kt, with the result that most of the Blue Boxes used for triggering various equipment failed to operate. Other than this difficulty, the data which were obtained from appropriate experiments all gave yield values which agreed, and the experiments which did operate gave satisfactory results. Blast measurements for this small-yield device correlated very well with the Tumbler 4 shot, which gave a much greater yield on a scaled basis.

Programs 10 to 20. [redacted]

Programs 21 to 29. Programs 23, 26, and 27 participated in this test involving small animals, neutron and gamma detectors, 50 FCDA and AEC vehicles, and various dosimeters. Satisfactory results were reported by the projects.

(e) On- and Off-site Fall-out. The cloud path followed the predictions closely, with considerable fall-out within the test area and no significant fall-out outside the test area. The cloud was followed by cloud-tracking planes as it moved in a southeast direction, north of Las Vegas and Boulder City, over the northern part of Lake Mead. It was tracked to about 40 miles

[redacted]

east of Boulder City, where it became too dissipated to follow farther. The contamination within the target area is shown in Fig. 5.32. By D+24 hr the access road to the blockhouse in Area 7 was just inside the 10 mr/hr line; therefore no operational delays were caused by the [redacted] contamination.

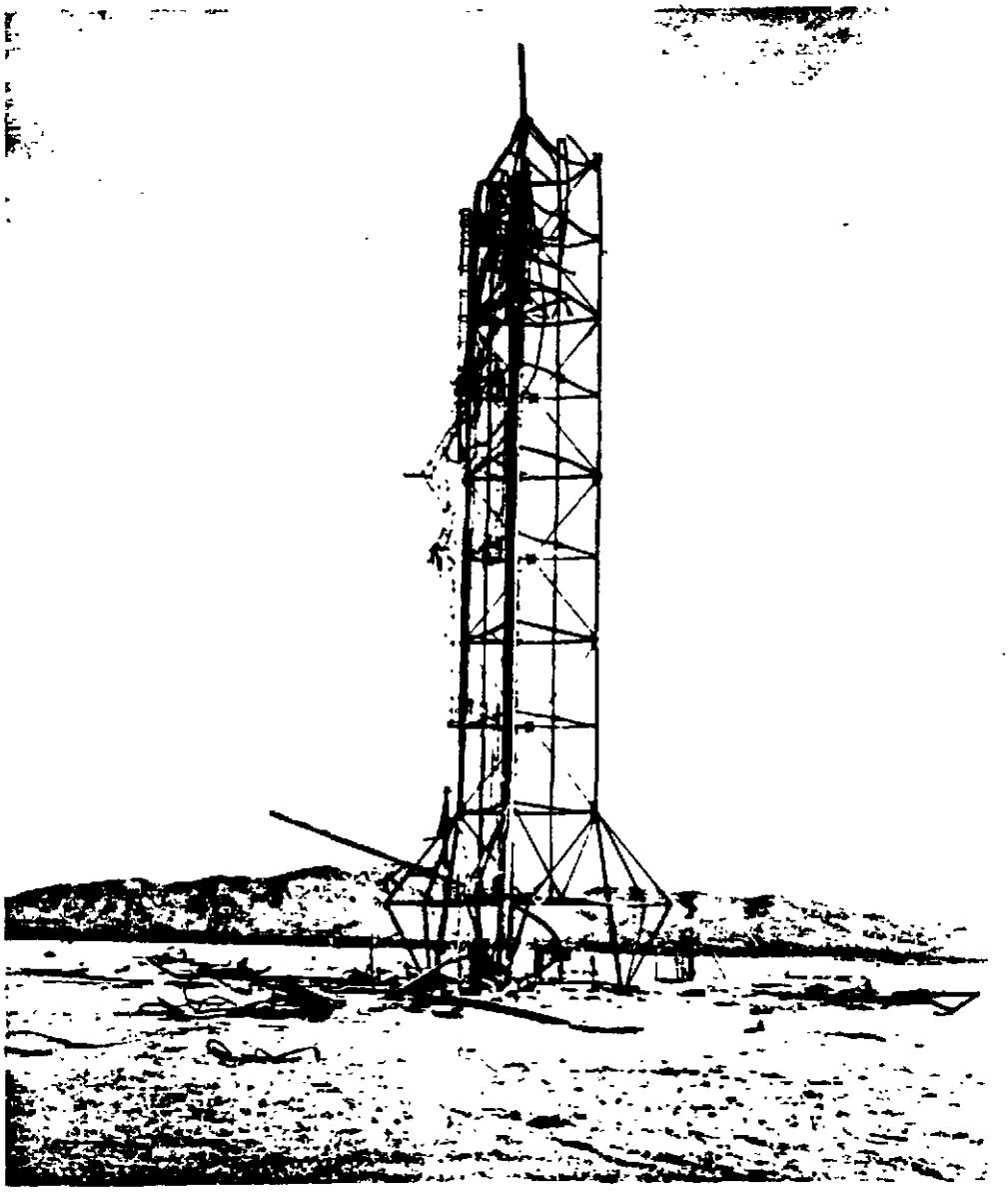


Fig. 5.31 [redacted] tower after detonation, Area 7-5a.

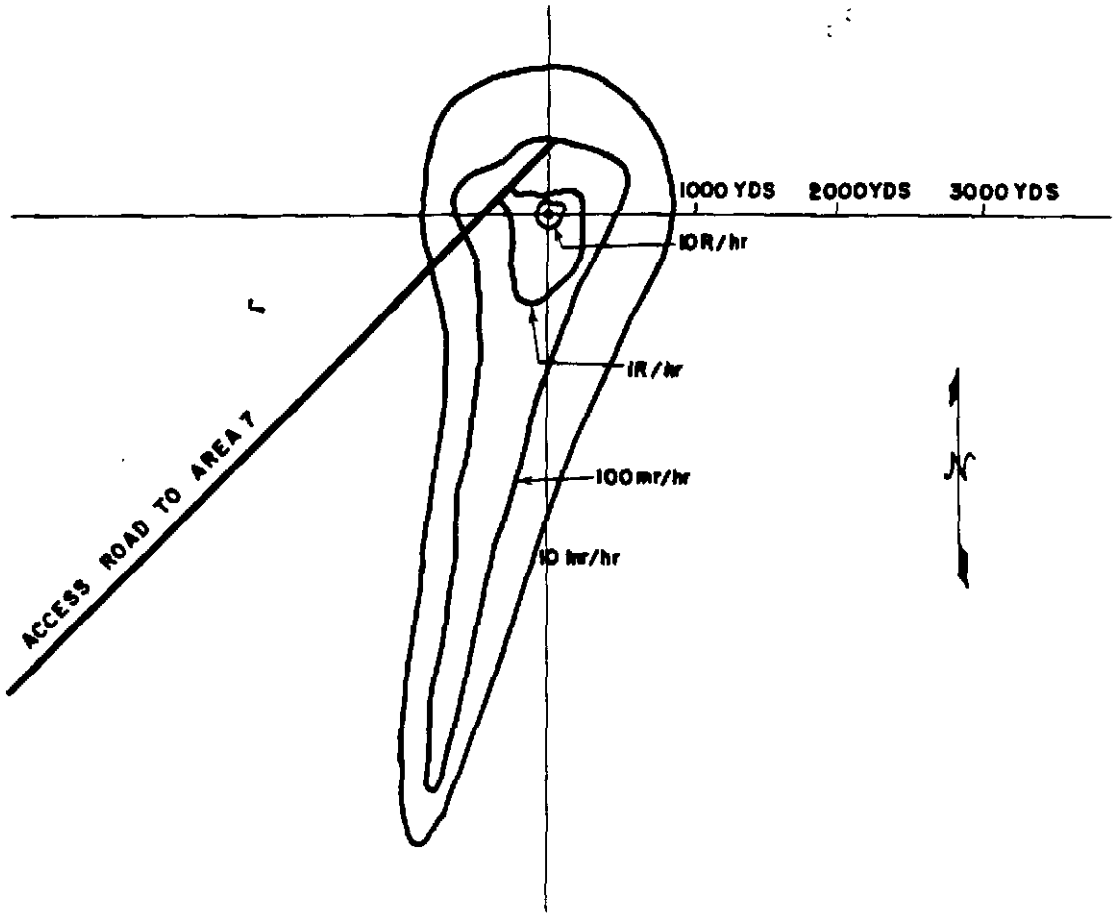
(f) Other Details of the Shot. There were no Desert Rock V exercises on this shot, and only official AEC, UCRL, LASL, and Sandia observers were present for the detonation.

5.3.4 [redacted] (See Sec. 2.1.4)

(a) General Preparations. Since the [redacted] was an airdrop, all assembly and loading operations were accomplished by the test organization Weapon Assembly and Nuclear As-

[redacted]

sembly groups who moved from NPG to Sandia Base for this shot. At the site the release-tone radio equipment in the control panel was operated during each signal dry run by an operator loaned to the test organization by Sandia. This man was also in charge of installation and maintenance of the release-tone radio equipment on the bombing aircraft. Since this was an



DETONATION TIME 0500 PST 31 MARCH 53
SURVEY TIME 0600 PST 31 MARCH 53

Fig. 5.32—Radiological situation, Area 7-5a, Yucca Flat, [redacted]

early morning (but daylight) shot, a standard USAF lighted target as well as a painted ground target was used, the lighted target because the aircraft entered the target area at about –2 hr, and at this time the painted ground target was barely visible.

(b) Meteorology. The burst height for the [redacted] was set for 6150 ft above terrain, and the estimated cloud height was 35,000 ft MSL. Under these conditions no dust stem was expected, and with the estimated yield of 11 Kt no serious fall-out problems were anticipated. At the 2100 hr weather briefing and Advisory Panel meeting on D–1 day, the Weather Officer forecast clear skies with no precipitation downstream within 500 miles. He did make a provision for possible high scattered cirrus clouds over the target area provided the weather front to the northeast did not move as predicted. A strong jet stream was present above 20,000 ft which would cause vertical but not lateral shear to the nuclear cloud. The winds aloft are shown in Table 5.5.

[redacted]

The Air Operations Officer stated that the jet stream would cause no bombing troubles but, if high cirrus cloud conditions prevailed, it was quite possible that the cloud-sampling operations would be handicapped. The prediction was that off-site blast would be negligible unless the upper wind velocities increased, in which case Las Vegas might experience damaging blast effects.

Table 5.5—WINDS ALOFT [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0100 PST, D-day		Actual winds at shot time, D-day		Actual winds at 1100 PST, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	Calm						330	14
6,000	250	08	340	15	300	03	190	10
8,000	300	20	310	19	310	13	220	08
10,000	320	25	260	17	280	28	280	08
12,000			270	29	280	33	280	23
14,000			270	36	280	48	300	38
15,000	320	35			280	31	300	57
16,000			290	40	280	34	280	60
18,000			290	48	290	64	290	67
20,000	310	50	280	54	290	72	290	56
25,000	320	65	290	37	290	68	290	74
30,000	320	75	290	83	290	92	290	70
35,000	320	80	300	117	290	60	290	78
40,000	310	50	300	64	290	122	290	98
45,000	310	40						
50,000	310	35						

* These data used by the Weather Officer during the 2100 PST Advisory Panel meeting.

On the basis of no radiological hazards and a gamble on cloud sampling, the decision was made to proceed with the shot.

(c) Detonation. [redacted] The burst height was set for 6150 ft above terrain. The actual burst height was 6020 ft. The circular error was 565 ft, being 80 ± 20 ft north and 560 ± 20 ft east of the Area 7-3 target. No dust stem was formed. The nuclear-cloud height was 43,000 ft with base at 31,000 ft, and very soon after the detonation considerable weather cloudiness occurred at nuclear-cloud height. There had been a small amount of cirrus before the detonation, making cloud-sampling conditions unfavorable, but the decision was made to go ahead with the shot. The upper air was supersaturated, and the increased cloudiness after the detonation made cloud-sampling operations very difficult. Therefore relatively poor samples were obtained. Figure 5.33 is a photograph of the [redacted] detonation over Area 7-3, Yucca Flat.

(d) Results. Detailed results are not given in this report because they are completely covered in the individual project reports in the Upshot-Knothole report series.

Programs 1 to 9. Programs 1, 2, and 4 to 9 participated as shown in the participation chart, Appendix A. Ground and free-air blast measurements were made with good results. The free-air data were obtained both from rocket trails and dropped cannisters containing telemetering equipment.

[redacted]



Fig. 5.33—Detonation of the [redacted] device over Area 7-3, Yucca Flat. The rocket trails are visible on the left, and for this high air burst no dust stem was formed.

[redacted]

Two USAF QF-80 drones operated satisfactorily with successful landings. Operating at 28,000 and 30,000 ft MSL, the first drone passed beneath the cloud just missing it, and the second drone penetrated the bottom of the cloud. All four monkeys and 116 of the 120 mice in the drones survived the missions and were recovered. The miss and near miss of the drones has been ascribed to the fact that the cloud rose faster than predicted, and that the device was released from the plane 20 sec early.

This was the most extensive military effects participation thus far in the Upshot-Knothole series. All projects reported highly successful results with no significant operational difficulties.

Programs 10 to 20. [redacted]

Figure 5.34 shows a rapatronic photograph of the [redacted] shot at 9.8 msec after detonation.

Programs 21 to 29. Programs 23 and 26 to 29 participated in the test, and all projects reported successful results. Fifty-seven automobiles were arranged in parking lot, city street, and double and triple parking arrays. Considerably greater thermal damage resulted to the automobiles from this high air burst than from the [redacted] tower shot.

(e) On- and Off-site Fall-out. The ground contamination at Ground Zero after this shot was 1.5 mr/hr, and no fall-out was recorded at any off-site location. The cloud moved very rapidly in the jet stream at 290°, passing north of Las Vegas and over Lake Mead at D+1 hr and north of Flagstaff and very much dissipated at D+3 hr. No Rad-Safe problems arose from this detonation.

(f) Other Details of the Shot. Desert Rock V participation consisted only of 135 observers who were at News Nob during the detonation.

Because this detonation was a mile above terrain in Yucca Flat, it was deemed advisable to establish road blocks on Highway 95 and to make press and radio announcements prior to the detonation in order to eliminate possible traffic accidents. The following public announcement was made the night before the detonation:

> In order to protect drivers of automobiles on Highway 95 against any possibility of temporary flash blindness, they will be halted during the hours prior to the detonation at four check points and will be advised of an approximate time at which they should pull to the side of the road, remaining halted until after the detonation.

These warnings were issued on the following schedule: north of Las Vegas, 0600 PST; at Death Valley Junction, 0630 PST; at Beatty, 0630 PST; and at Indian Springs, 0630 PST. No automobile accidents resulted.

5.3.5 [redacted] (See Sec. 2.1.5)

(a) General Preparations. The original plans were to detonate [redacted] on a 50-ft steel tower. A tower of simple design, which could be erected at the zero point in Area 4a after the [redacted] detonation in Area 4, was fabricated. However, three weeks before the actual detonation the Test Director decided it was advisable to increase the height of this tower to 100 ft because estimates of yield [redacted] On March 16 it was requested that the tower height be increased to 100 ft, and the 100-ft tower was erected [redacted] detonation. There was no elevator in the tower; an ordinary rigger's hoist was used to raise the [redacted] device.

Page 68 is deleted

[redacted]

All nonnuclear assembly and moving operations were done by the Test Director's Weapons Assembly Group, but the nuclear assembly was done by a UCRL group. The [redacted] was put in the tower cab on the morning of D−2 day. The last signal and power dry run was made at 1000 PST on D−1 day, and the nuclear insertion was made at 1530 PST on D−1 day.

(b) Meteorology. At the 2100 PST weather briefing and Advisory Panel meeting on D−1 day, the Weather Officer forecast the winds aloft as shown in Table 5.6, with clear skies and no precipitation downstream within 300 miles.

On the basis of 0.3-Kt yield, the estimated cloud height was 15,000 ft. Fall-out was predicted south of the target within the test-site area and just outside it. The Air Operations Officer stated he would have cloud samplers available 5 min after the detonation and felt sure he could guarantee early samples; however, because the cloud would dissipate rapidly, late sampling was doubtful.

Table 5.6—WINDS ALOFT [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0100 PST, D-day		Actual winds at shot time, D-day		Actual winds at 0700 PST, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	360	05					Calm	
6,000	340	15	350	27	360	18	010	12
8,000	330	20	360	22	360	31	010	22
10,000	320	30	350	15	360	31	010	17
12,000			340	10	360	23	340	18
14,000			310	15	350	23	330	17
15,000	310	40			310	28	330	16
20,000	300	50					310	53
25,000	300	65					290	88

* These data used by the Weather Officer during the 2100 PST Advisory Panel meeting.

(c) Detonation. The [redacted] was detonated on a 100-ft four-legged steel tower in Area 4a at 0444:59.781 ± 0.001 sec PST, 11 April 1953. The 100-ft steel tower was completely destroyed.

(d) Results. Detailed results may be obtained from the individual project reports, which are a part of the Upshot-Knothole report series.

Programs 1 to 9. The military effects interest in this detonation was very minor. Programs 6, 7, and 8, only, participated in this shot. All projects reported satisfactory results.

Programs 10 to 20. [redacted]

Programs 21 to 29. Personnel of Program 22 who were to participate in this test did not arrive at the test site in time for the detonation. The only remaining projects making tests were 29.1 and 29.3, which reported satisfactory results.

(e) On- and Off-site Fall-out. The on-site ground-contamination plot as made about 1½ hr after shot time is shown in Fig. 5.36. This plot is of Area 4 and includes the residual contamination left from the [redacted] shot made on March 24, as well as that from the [redacted] detonation. By comparing this plot with that shown in Fig. 5.29 for th[redacted] it is seen that the southerly surface "drainage" wind characteristic of the Yucca Flat area carried the low contaminated dust cloud south, passing just west of the control point

[redacted]

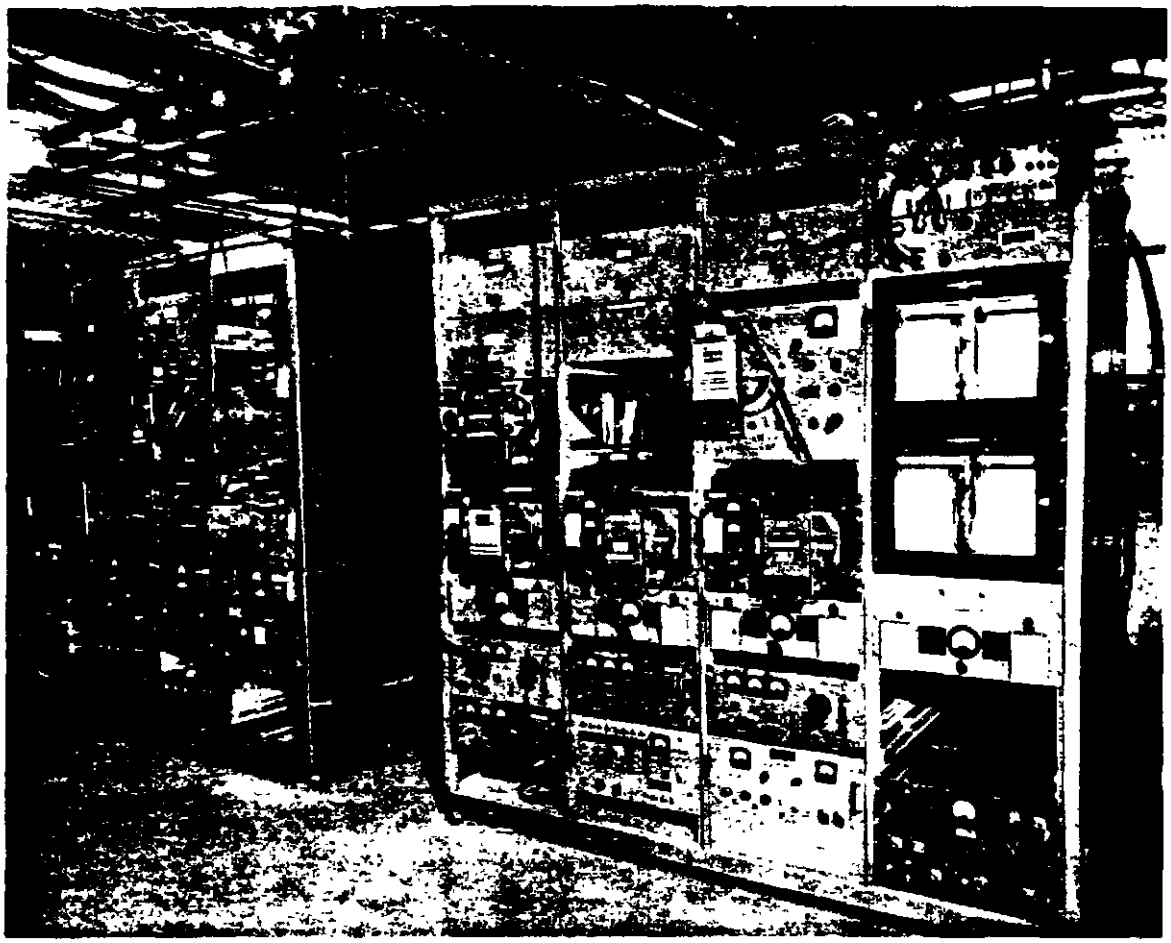


Fig. 5.35—Alpha-recording equipment in Station 300, Area 4.

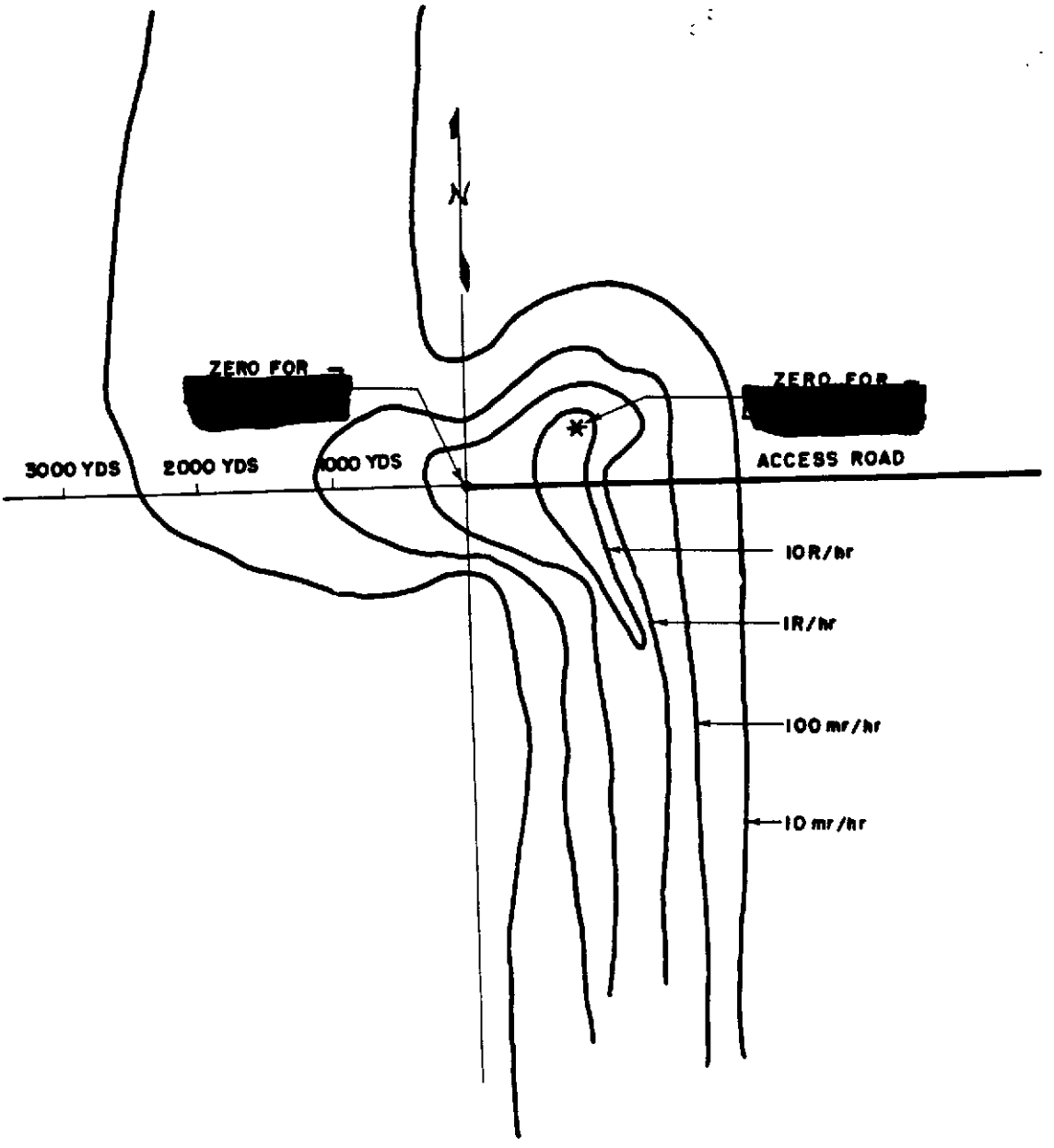
through a gap in the mountain range forming the west boundary of the proving ground and then, as shown in Fig. 5.37, down across Highway 95 and over Death Valley at +3 hr. The cloud reached a height of 13,000 to 14,000 ft MSL, making the height above terrain only 10,000 ft in the valleys and much less in the surrounding mountains. No significant fall-out occurred in any populated area.

(f) Other Details of the Shot. Desert Rock V exercises were limited to only 63 observers, 35 being "repeats," stationed at News Nob. There were no other significant details connected with this detonation.

5.3.6 [redacted] (See Sec. 2.1.6)

[redacted]

[redacted]



DETONATION TIME 0445 PST 11 APRIL 53
SURVEY TIME, 0630 PST 11 APRIL 53

Fig. 5.36—Radiological situation, Area 4, Yucca Flat [redacted]

[redacted] DATA

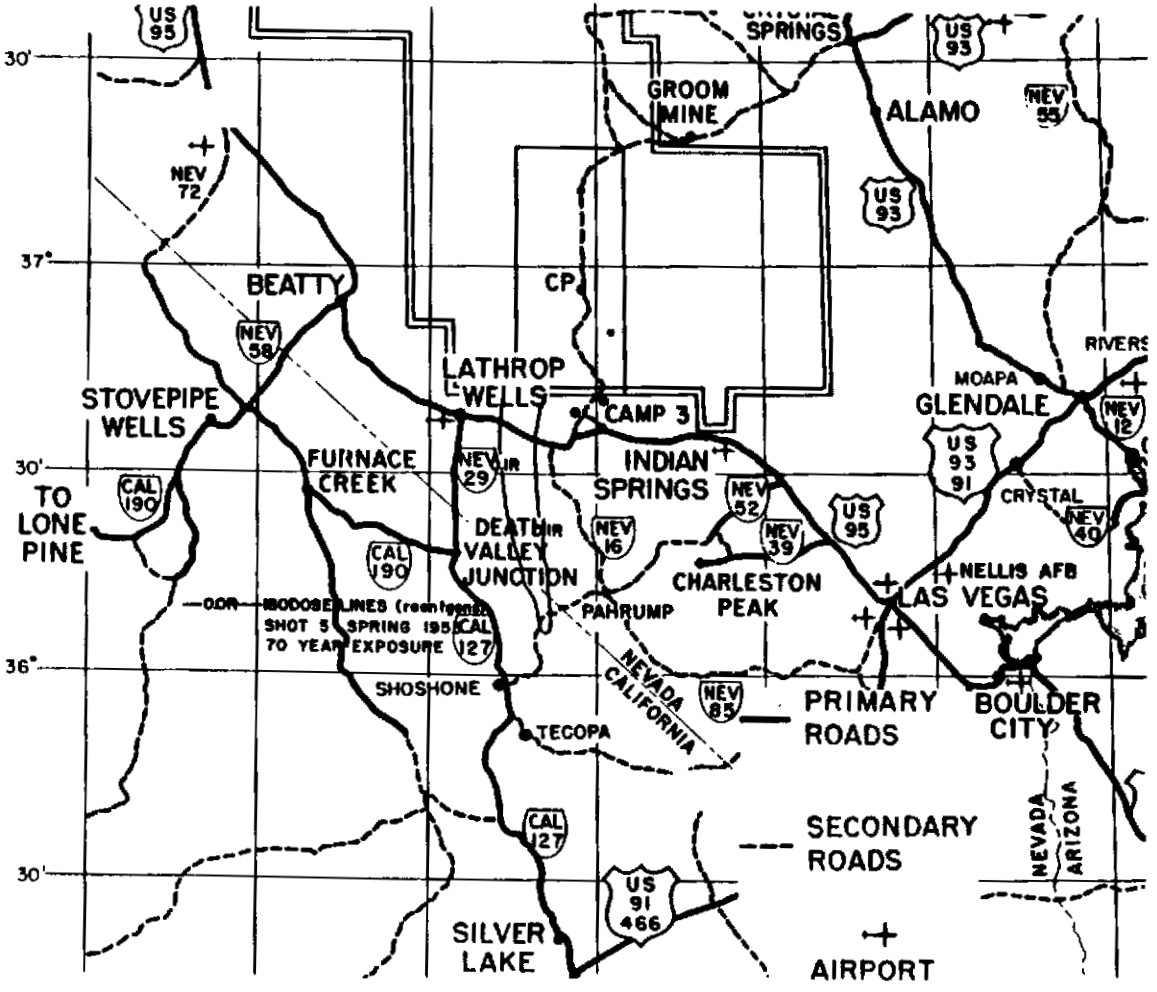


Fig. 5.37—Off-site fall-out from [redacted] detonation.

[redacted]

Table 5.7—WINDS ALOFT, [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0200 PST, D-day		Actual winds at shot time, D-day		Actual winds at 0700 PST, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	315	3					360	11
6,000	Calm		360	18	010	24	020	15
8,000	210	15	290	09	290	06	340	10
10,000	250	20	250	15	270	17	300	23
12,000					280	26	310	26
14,000					310	30	310	27
15,000	270	35	310	38	320	30	290	30
16,000					310	30	290	31
18,000					300	33	330	30
20,000	270	50	290	43	290	35	350	34
25,000	270	55	290	48	290	43	310	47
30,000	270	60	290	51	310	46	310	43
35,000	270	65	280	60	300	54	310	52
40,000	270	70	280	75	300	68	310	43
45,000	270	35			280	52	310	13
50,000	270	30						

* These data used by the Weather Officer during the 2100 PST Advisory Panel meeting.

[redacted]

(b) *Meteorology.* The Weather Officer presented the wind pattern shown in Table 5.7 at 2100 PST on D−1 day, at the weather briefing and Advisory Panel meeting. The presence of a front in the vicinity of the proving grounds made the wind predictions subject to a 10° shift at

[redacted]

shot time. No downwind precipitation was predicted within 1000 miles, and clear to high scattered cirrus clouds were forecast. The 48-hr forecast was practically the same.

The predicted nuclear-cloud height was 44,000 ft. On the basis of the wind pattern little vertical shear was expected, with concentrated fall-out from the cloud stem in the general direction of St. George in 5 hr, and Caliente in 3 hr. The off-site blast effect was expected to be concentrated in a sector 42 miles northeast and southeast but was not expected to be heard at Indian Springs or Las Vegas. Some consternation was expressed by the advisors over the possibility of fall-out on St. George, which had already received fall-out from the [redacted] shot. Since the path was expected to be north of St. George, the decision was made to proceed with the shot but to examine the wind data closer to shot time for possible changes in cloud motion.

(c) Detonation. [redacted] was detonated on a 300-ft 30-ton three-legged steel tower in Area 2, at 0434:59.958 ± 0.002 sec PST, 18 April 1953. [redacted] The top of the nuclear cloud reached 37,200 ft.

(d) Results. Detailed results of this shot are contained in the separate reports in the Upshot-Knothole report series, and only general results will be presented here. [redacted]

Programs 1 to 9. Programs 2 and 4 to 8 participated in this detonation. Program 2 got satisfactory data for both projects conducting experiments. In Program 5, one of the drone planes experienced a mishap on takeoff which resulted in the cancellation of that test. The remaining projects in Programs 6, 7, and 8 reported essentially satisfactory results. In the flash-blindness experiment, 130 rabbits were exposed at ranges of 3 to 17 miles and received skin and fur burns at 3 miles and retina burns at 17 miles. Twelve human subjects were involved in a flash-blindness experiment, with satisfactory results reported. The flash-blindness experiments for five Upshot-Knothole shots are summarized in Report UKP-72, page 99, as follows:

> Men looked at the initial flash of an atomic bomb with the dark-adapted eye for the period of the blink reflex through red filters which screened out most of the visible and infrared radiation except that between 600 and 680 millimicrons. A total of 55 exposures was made on five shots at distances ranging from 7 to 14 miles. In no instance did the men receive retinal burns from these exposures and the vision recovery time for reading red-lighted aircraft instruments after the exposures averaged about 20 sec. This vision recovery time is probably about 25 per cent less than that which would have been required had exposure been made without filters. Thus the filters offered adequate protection against retinal burns under the conditions of these experiments and reduced appreciably the time required to read aircraft instruments under standard conditions of illumination at night. This type of filter is considered useful for wear as protection for the vision of aircraft crew members in those situations where it may be anticipated that an atomic flash might be viewed at night at distances of a few miles.
>
> In dark-adapted rabbits, unprotected by filters, exposed to the flash of an atomic bomb, burns of the retina were obtained at distances from 2 to 28.5 miles with 3 possible but questionable burns being obtained at 42.5 miles. This does not mean that the retina of man would necessarily be burned by the flash at these distances. However, retinal burns have sometimes occurred in man on unprotected exposure to the flash at 10 miles or less and retinal burns at greater distances are considered to be entirely possible.

Programs 10 to 20. [redacted]

[redacted]

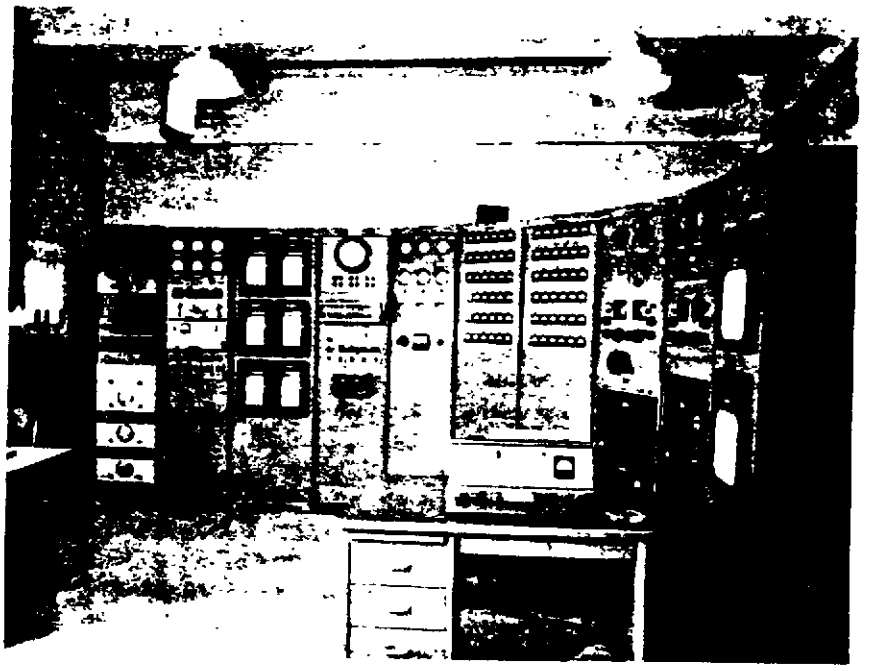


Fig. 5.38—Control board in the control room, NPG [redacted]

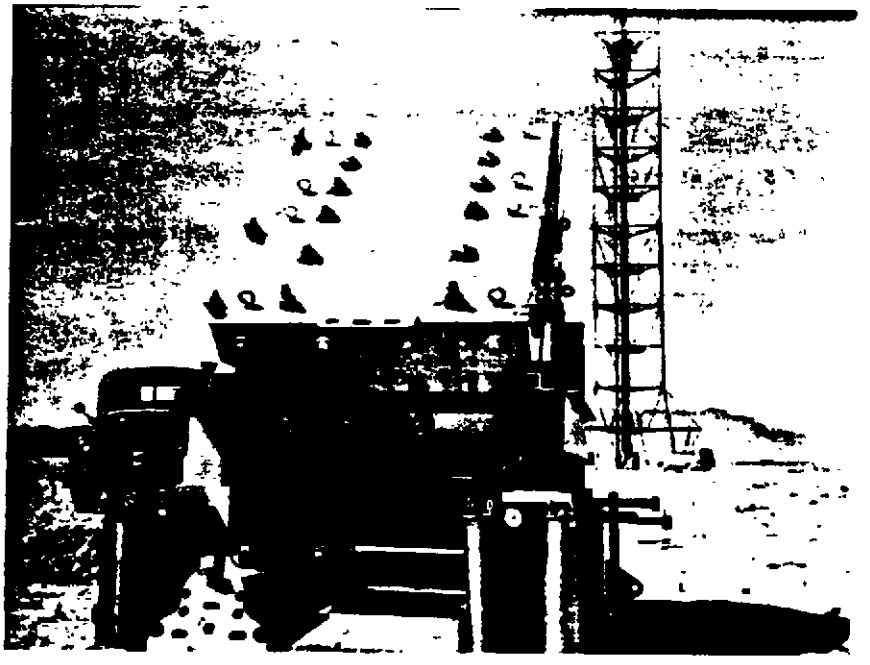


Fig. 5.39—Collimator block used in neutron measurements. (Projects 17.1 and 17.2 [redacted] shot.)

[redacted]

[redacted]

Programs 21 to 29. Programs 22, 24, and 27 to 29 participated in this test. Much of the experimental equipment involved in these programs was located and emplaced on D−1 day, based on predicted nuclear-cloud movement. The early predictions did not verify, resulting in no data for some of the projects. For those stations close to zero, satisfactory data were obtained.

(e) On- and Off-site Fall-out. Complete Rad-Safe operations are contained in the Rad-Safe report in the Upshot-Knothole series. As shown in Table 5.7, the wind direction changed considerably from that predicted, resulting in a cloud motion south of east for the higher levels. At low levels and inside the test area, the cloud moved southeast, with considerable ground contamination resulting in Areas 2, 3, and 7.

The on-site ground plot of contamination right after the [redacted] shot is shown in Fig. 5.40. This plot shows the high levels which resulted on the main access road to the test areas, as well as the general contamination throughout the Yucca Flat area. Rad-Safe signs indicating the levels were placed along all access roads, other unused roads were blocked, and work was slowed down somewhat owing to the contamination problem.

The off-site fall-out chart is shown in Fig. 5.41. It is seen that the heaviest fall-out in a populated area occurred around Overton Landing on the northwest end of Lake Mead. The total population in this area was only 15 people, however, and the maximum lifetime dose possible was 9 r. The high-level part of the nuclear cloud moved rapidly southeast, over Lake Mead at +2 hr and over Flagstaff, Ariz., at +5½ hr.

(f) Other Details of the Shot. Desert Rock V exercises for the [redacted] shot consisted primarily of Marine Corps activities, with 2084 troops, 611 observers, and 40 Marine Corps Sikorsky (HRS) helicopters participating. The troops and troop observers were situated 4000 yd southeast of Ground Zero in 6-ft-deep trenches at shot time. After the shot the troops advanced toward Ground Zero along with the 40 helicopters. A sudden shift in surface winds moved the dust cloud over the troops, necessitating a quick maneuver to the west. No difficulties were encountered.

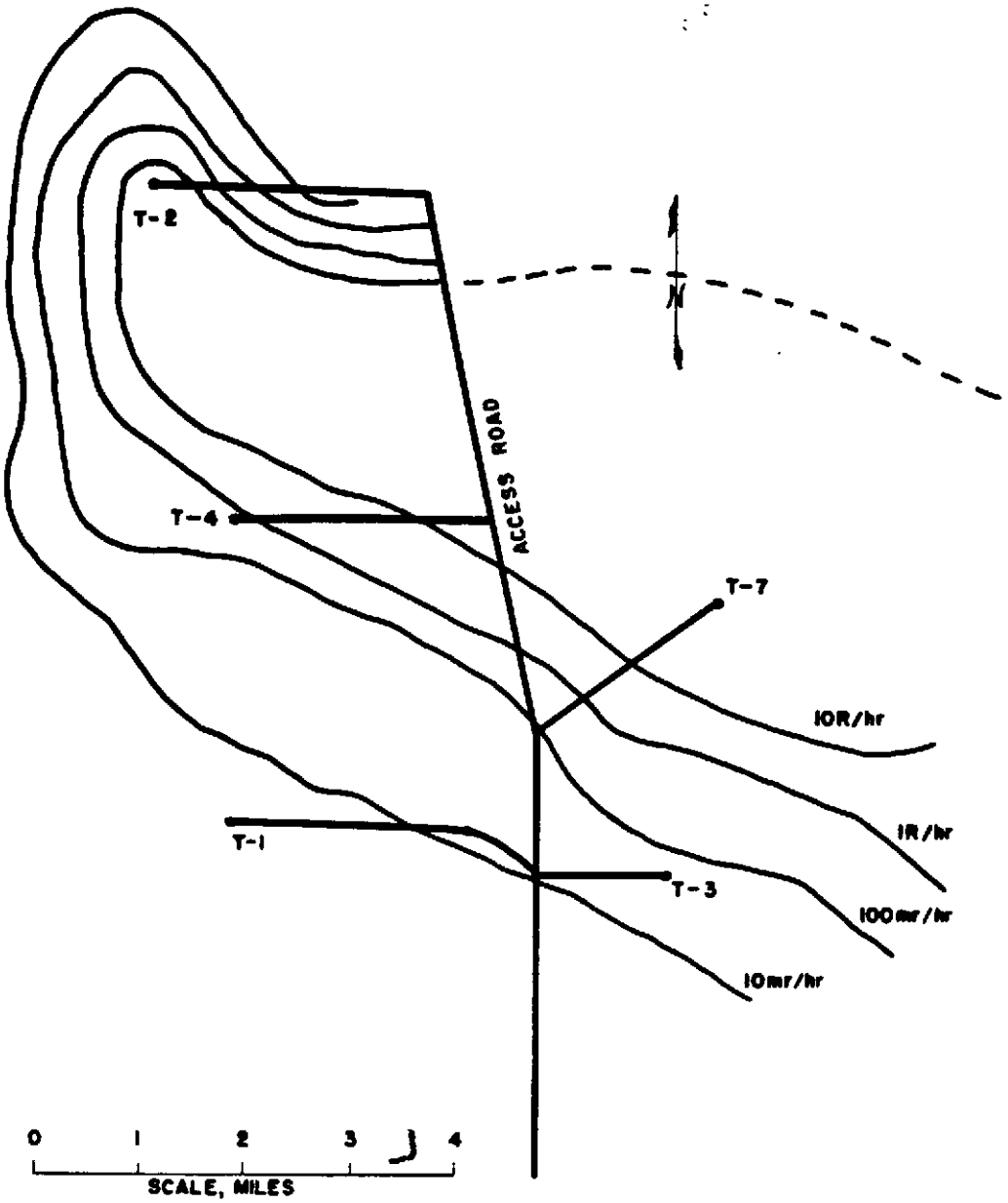
Also as part of the Desert Rock exercises, 12 officer volunteers (6 Army, 6 Marine) were entrenched 2000 yd and on an azimuth approximately 195° from Ground Zero. No ill effects from blast or flying debris were encountered. The film-badge readings of these 12 personnel gave total doses in roentgens for the exercise as follows: 5.3, 5.2, 5.2, 8.5, 4.6, 6.3, 4.1, 4.9, 9.6, 5.2, 7.9, and 6.6, or an average of 6.1 r.

5.3.7 [redacted] (See Sec. 2.1.7)

(a) General Preparations. The nature of the optical instrumentation (Project 12.2) associated with the [redacted] shot required that the [redacted] be installed in the tower cab in its proper position approximately 30 days before shot time.

[redacted]

[redacted]



DETONATION TIME, 0435, 18 APRIL 53
SURVEY TIME, 0800, 18 APRIL 53

Fig. 5.40—Radiological situation, Yucca Flat [redacted] shot.

[redacted]

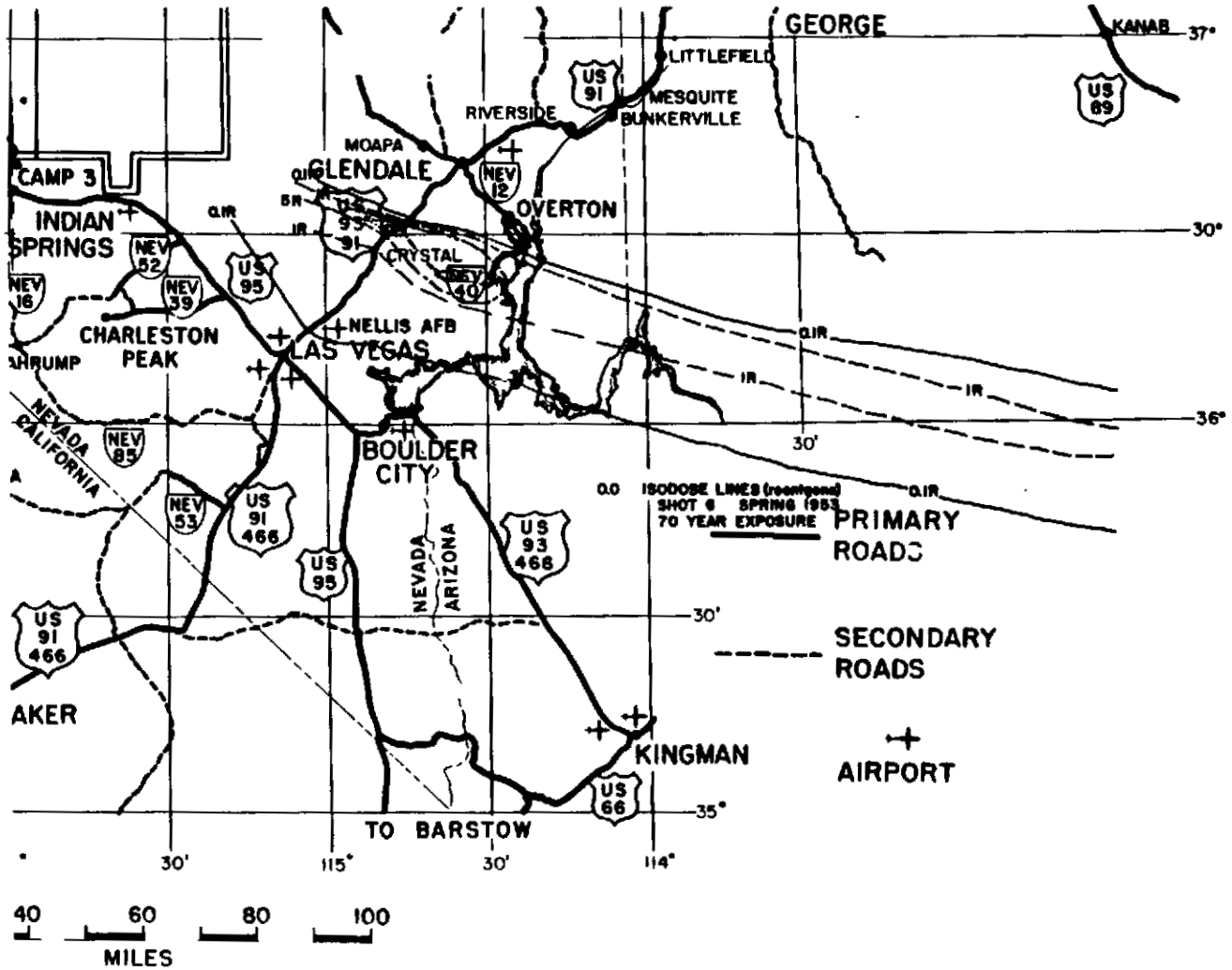


Fig. 5.41 —Off-site fall-out from [redacted] detonation.

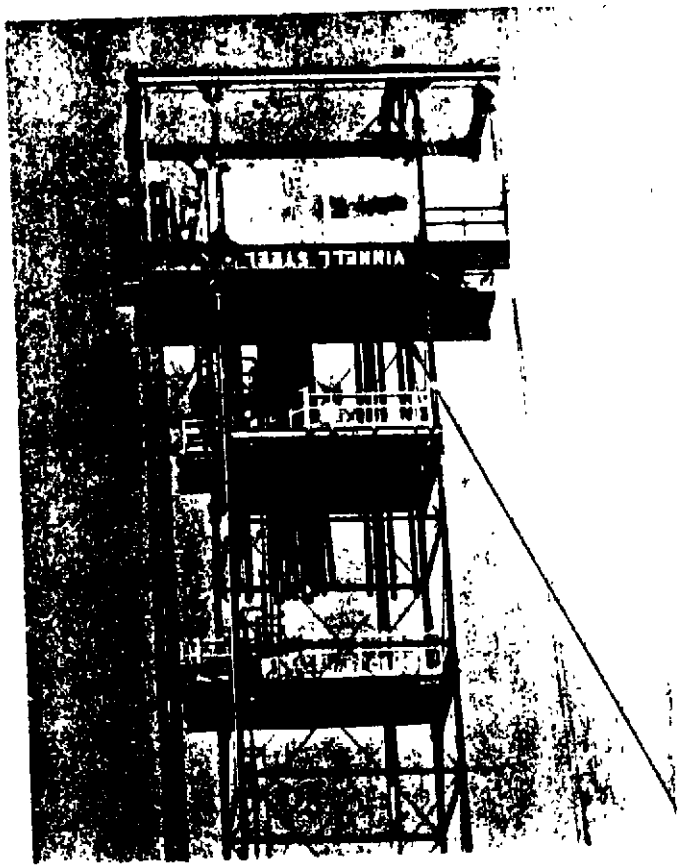


Fig. 5.42—Top section of 300-ft 30-ton steel tower [redacted] shot. [redacted]

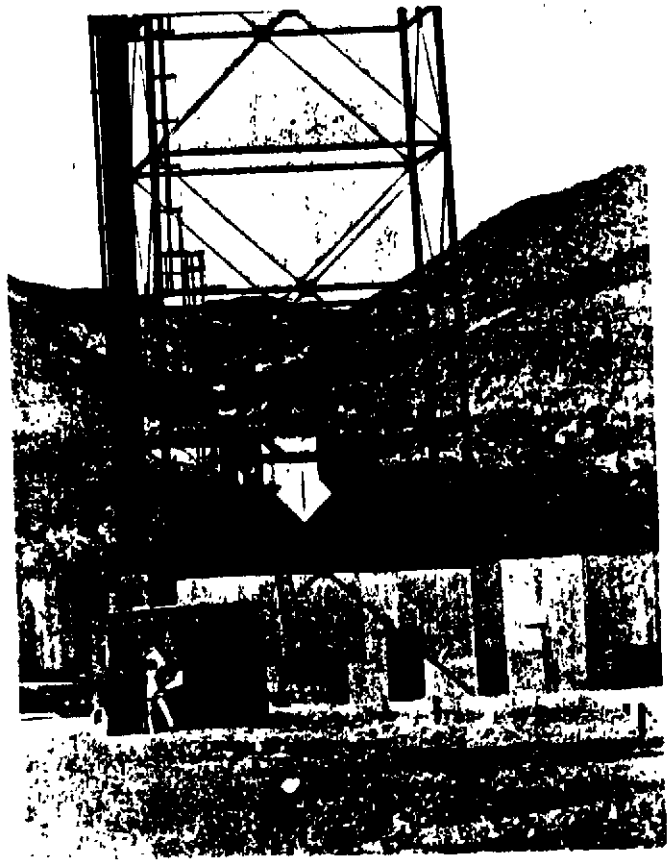


Fig. 5.43—Base of tower used fo[redacted]shot. Housing around the mirror mounts used by Project 12.2 is shown.

An incident occurred in connection with the X-unit for this device which was disturbing. The batteries and the inverters were installed in the EG&G rack in the tower cab. The output leads of the 400 cycle inverters were paralleled on the rack and, from the rack terminals, cables went to the converters in the X-unit. During signal dry runs the Firing Party Chief noted the inverters operated at slightly different speeds causing a "beating" sound. Also the

Table 5.8—WINDS ALOFT [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0230 PST, D-day		Actual winds at shot time, D-day		Actual winds at 0700 PST, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	360	03					Calm	
6,000	040	05	020	13	030	08	080	09
8,000	300	15	070	05	070	03	140	04
10,000	290	20	200	03	280	09	270	07
12,000					280	12	270	12
14,000					270	11	250	09
15,000	260	25	290	12	290	09	250	10
16,000					280	08	220	09
18,000					270	26	310	13
20,000	260	30	270	17	280	26	280	18
25,000	250	35	290	25	280	20	280	28
30,000	240	40	280	25	280	41	280	26
35,000	240	40	280	40	280	36	280	26
40,000	240	25	270	39	270	48	280	43
45,000	240	20			270	30	280	37

*These data used by the Weather Officer during the 2100 PST Advisory Panel meeting.

capacitor voltage on the output of the converters dropped below the minimum operating voltage for proper detonation function. The cause of this difficulty was sought, and the effect was eliminated by increasing the size of the output leads from the inverters to the terminals on the EG&G rack.

The only other major problem which developed prior to the shot was the development of rapidly closing doors at Station 1-380 for Project 12.2. During the [redacted] shot the doors covering the apertures for a similar station did not close before the shock arrived, and serious damage to equipment in the station resulted. The time between getting the data and arrival of the shock at the station was only 280 msec; therefore the blastproof doors had to close in this short time interval. Improvements in the mechanical design of the closing mechanism were worked on during the interval between the [redacted] shots and it was not until the afternoon of D−1 day for the [redacted] shot that the mechanism was finally considered satisfactory.

(b) Meteorology. The Weather Officer presented the wind forecast, shown in Table 5.8, at the 2100 PST weather briefing and Advisory Panel meeting on D−1 day. He stated that a ridge moving east about 10° each 24 hr would probably be through eastern Nevada at shot time. The winds at all levels were predicted to be lighter than usual. Predicted cloud conditions were $^{5}/_{10}$ cirrus above 30,000 ft, with no precipitation downstream within 1000 miles.

The nuclear-cloud height for this shot was estimated to be 42,000 ft. In the preceding detonation [redacted] the prediction was higher than the actual height; therefore it was pointed out that the actual nuclear cloud might reach only 37,000 ft. Low-level fall-out was predicted to reach Las Vegas in about 9 hr, with the principal fall-out occurring northeast of St. George. It was predicted that a high-level hot spot would remain in the target area, including Area 3.

[redacted] DATA

The Air Operations Officer stated that he would be able to obtain samples. Except for the concern over possible heavy fall-out in the target area, which might jeopardize the Naval Research Laboratory (NRL) thermal trailer and the EG&G phototrailer film records, there was no objection to having the detonation.

(c) Detonation. The [redacted]evice was detonated on a 300-ft 100-ton four-legged steel tower in Area 1, Yucca Flat, at 0429:59.763 ± 0.001 sec PST on 25 April 1953.

Actual cloud cover	5/10 at 33,000 ft 3/10 at 16,000 ft
Nuclear-cloud height	45,000 ft

The usual two 2400-lb TNT charges were detonated for the microbarographic group at −2 and −1 hr.

(d) Results. Detailed results covering all experiments performed by the various projects participating in the shot will be found in separate reports forming part of the Upshot-Knothole report series.

Programs 1 to 9. Some projects in all programs participated in this shot. In Project 5.1 the Navy drone operation was successful until the time of the blast. The timing of the drone operation was 1 sec short and this coupled with a larger yield (approximately 50 Kt) than expected subjected the drone to more severe excitation than had been planned. The drone was 5900 ft above the zero point at a slant range of 6160 ft at zero time. Immediately following the detonation the drone developed a smoke trail but flew straight and level until shock arrival at +3.7 sec, when the drone went into a vertical dive and crashed. Posttest analysis showed that the aircraft failed principally because of the thermal radiation, which weakened the structure prior to shock arrival. Standard blue aircraft paint proved clearly inferior to white or unpainted metal surfaces for protection against destructive thermal effects.

The remaining projects in the DOD programs reported completely satisfactory results.

Programs 10 to 20. [redacted]

Programs 21 to 29. Programs 22 and 27 to 29 participated in this shot. In Project 22.1 the FCDA arranged for 16 men from various parts of the country, all engaged in state civil radiological defense organizations, to participate in a training course during the period of this test.

With the exception of Project 28.1, all civil effects projects participating obtained good results. Project 28.1 (radiological telemetering) installed instruments in the predicted fall-out pattern on D−1 day, and, since there were significant wind shifts, the equipment showed no radiation, although it did function properly.

Program 27 had stations located in a sector which very satisfactorily bracketed the fall-out pattern, the stations being located at distances 15 to 86 miles from zero. Good data were obtained.

(e) On- and Off-site Fall-out. The yield [redacted] was slightly greater than anticipated, and ground contamination on the main access roads and at several of the instrument stations in the Yucca Flat area prevented early Rad-Safe survey operations. Several recovery parties were admitted to the test area by the Test Director before recovery hour

[redacted]

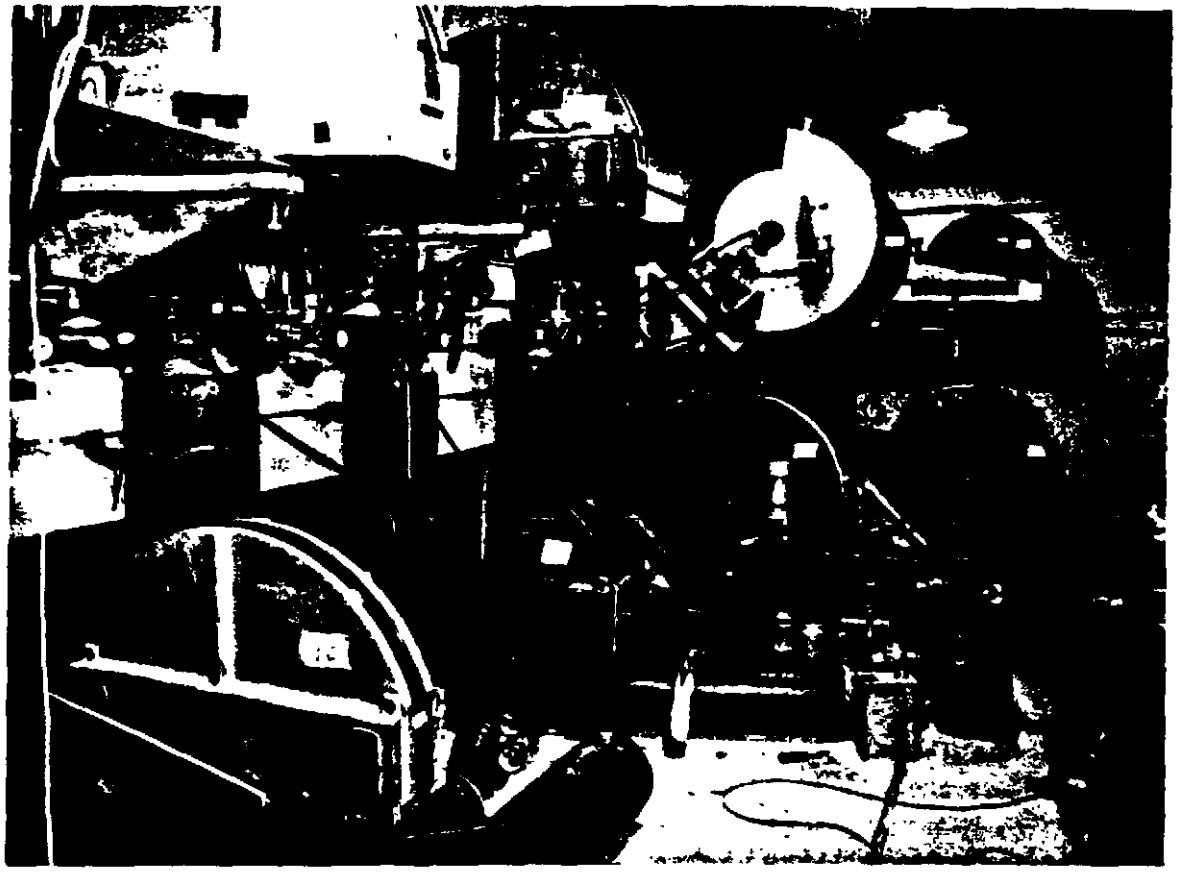


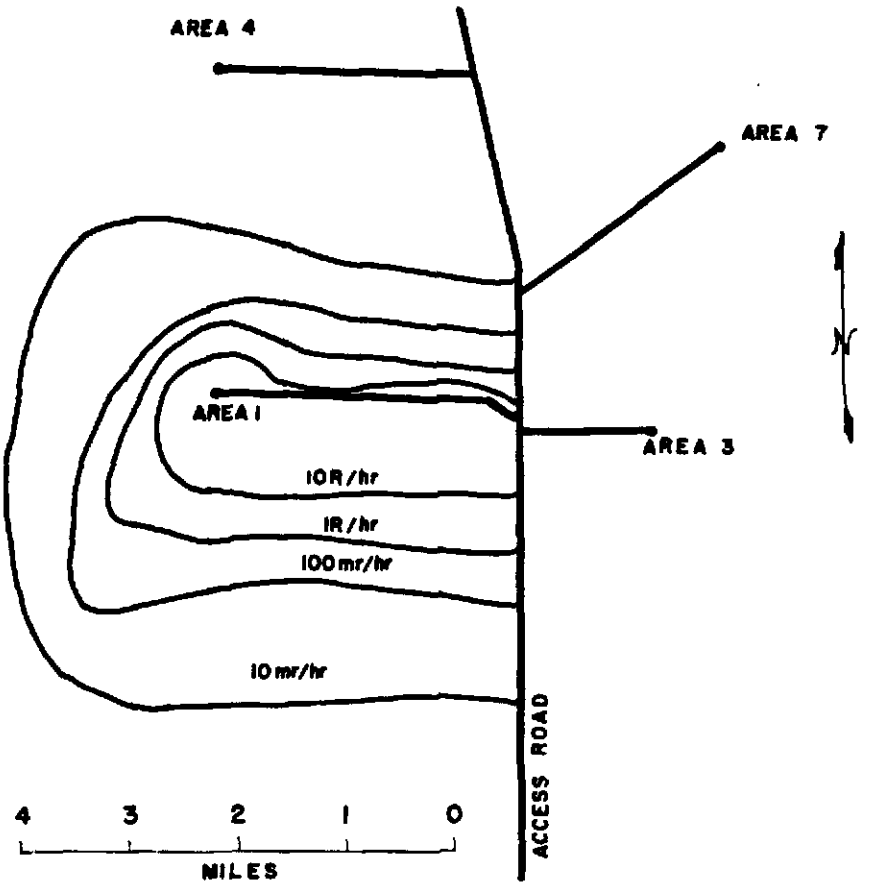
Fig. 5.44—Interior of camera room, Station 1-380. Array of models 6 and 100 ultra-high-speed cameras for [redacted] shot are shown.

was announced at D+8 hr. In Fig. 5.45 the ground contamination is shown on the west side of the main access road and around Area 1 at D+3 hr. A more complete survey of the Yucca Flat area is shown in Fig. 5.46, at D+10¼ hr. [redacted]

The off-site fall-out pattern [redacted] is shown in Fig. 5.47. The wind pattern at shot time shifted approximately 25 to 30° southeast from the predicted direction, carrying the cloud just north of Glendale and over Riverside, Bunkerville, and Mesquite, Nev. The fall-out on Highways 91 and 93 north of Glendale was sufficient to justify the Test Director's requiring that road blocks be established at prearranged monitoring points. Radio communications were good between the Rad-Safe control center in the Control Building at the proving grounds and the mobile monitoring teams out along the highways and in the populated areas. This was the first time for any of the continental tests that road blocks, established for monitoring vehicles, were considered necessary. The complete record of events in the off-site monitoring operations is contained in a report of the Rad-Safe group. Vehicle-contamination checks were established at St. George, Utah, Alamo, Nev., and North Las Vegas, Nev. If the vehicle showed a reading of 7 mr/hr or greater inside the car, the monitor requested the owner to take the vehicle to a previously established car-washing place and have the car washed at AEC expense. In all 25 cars were washed at St. George, and 15 cars were washed at Las Vegas. The owners of the vehicles apparently were not displeased by this action; none

[redacted]

refused, and cooperation was exceptional considering this was Saturday afternoon traffic. The over-all operations pointed out several deficiencies in the emergency operational plan for such eventualities. Since the remaining four shots in Operation Upshot-Knothole were reasonably large yield devices, the Test Manager, the Test Director, and the Las Vegas Field Manager considered revisions to the emergency plan which it was expected would greatly expedite monitoring cars, washing cars, and other precautionary operations connected with fall-out in populated areas.



DETONATION TIME 0430, PST, 25 APRIL 53
SURVEY TIME 0730, PST, 25 APRIL 53

Fig. 5.45—Radiological situation, Area 1, Yucca Flat [redacted]

(f) Other Details of the Shot. Desert Rock V Exercises. The largest number of Desert Rock personnel to date participated in this shot. Involved were 2450 troops and 584 observers, all but 8 being located in trenches 4000 yd from zero at detonation time. In the tactical exercises the Battalion Combat Team at the east moved forward only to within 2000 yd of zero because of the 2.5-r level at that point, but the Battalion Combat Team to the west was able to advance to the objective west of Ground Zero. Four Marine helicopters participated in the maneuvers. Eight volunteers (7 Army, 1 Navy) were positioned in trenches 6 ft deep and 3 ft wide at 2000 yd from Ground Zero at detonation time.

[redacted]

Observers. During the earlier part of the test series, the Chairman of the Joint Congressional Committee on Atomic Energy invited all senators and representatives in Congress to witness one of the last four tests in the series. Fourteen congressmen witnessed the detonation of the [redacted] shot.

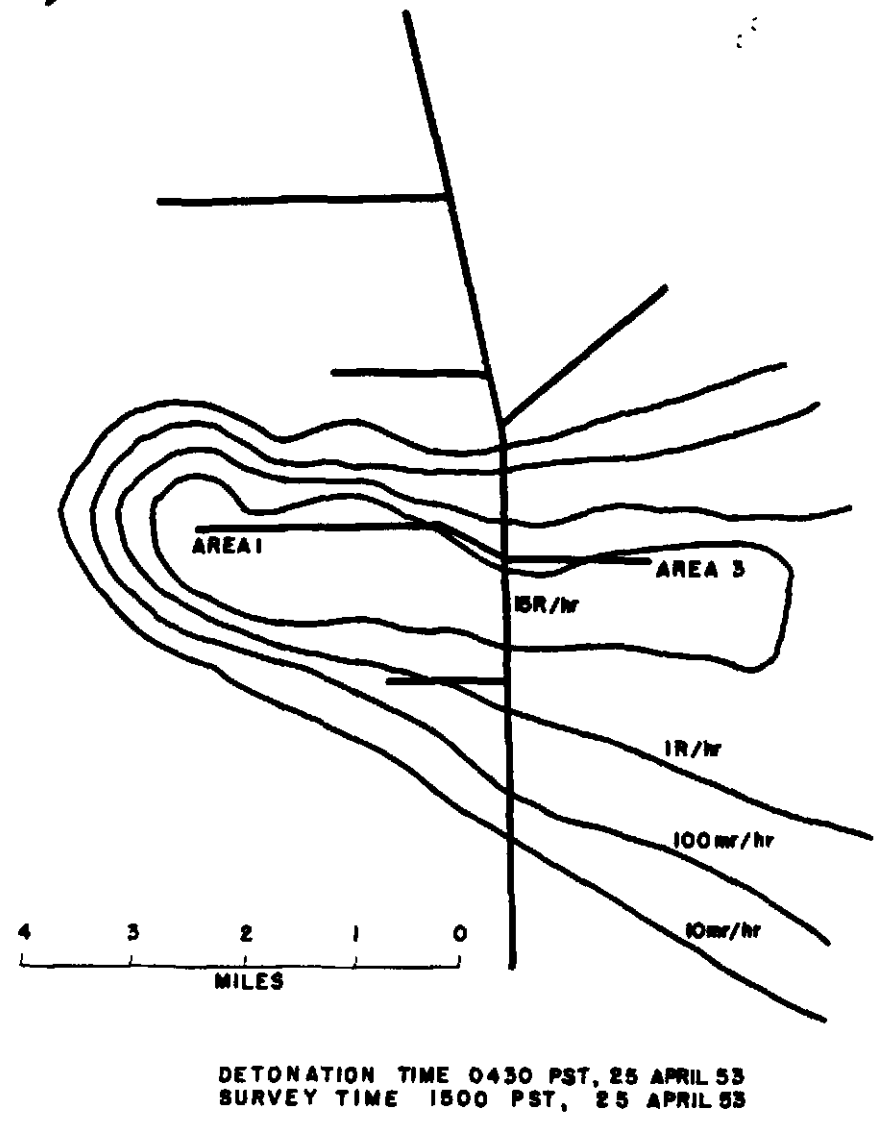


Fig. 5.46—Radiological situation, Area 1, Yucca Flat [redacted]

5.3.8 *Dry Run Prior to Effects*

Because the test personnel involved in the Effects shot were people largely without previous test experience, because the test program involved a several million dollar installation, and because the Frenchman Flat area had not as yet been used in the Upshot-Knothole series, it was considered advisable to have a complete dry run prior to the Effects shot. The dry run was scheduled to be held three days prior to the Effects shot. [redacted] The aiming zero was the zero to be used for the Effects shot, and the detonation time was set for 0830 PDT, the same as for the Effects shot.

[redacted]

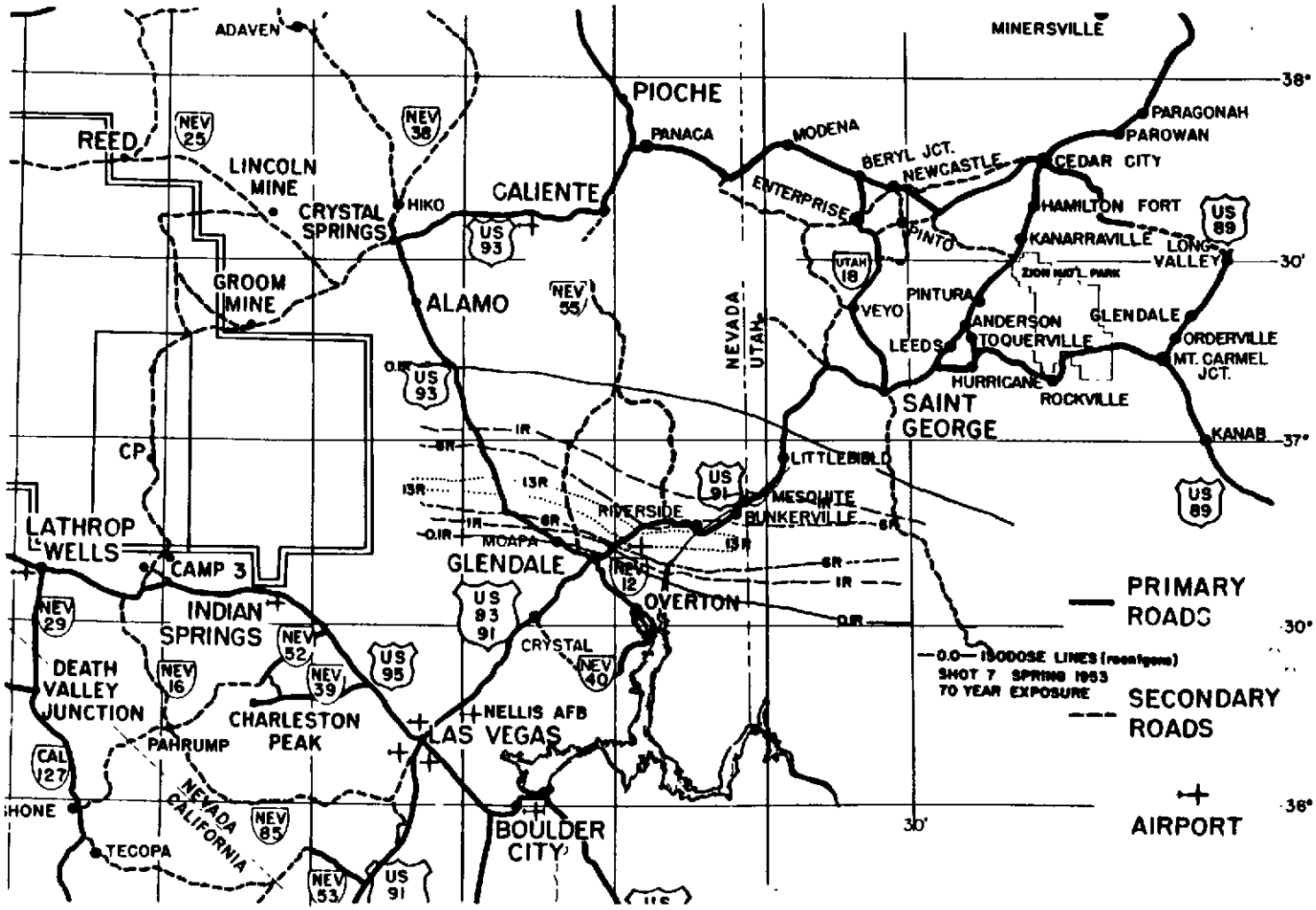


Fig. 5.47—Off-site fall-out from [redacted] detonation.

The weather meeting held at 0830 PDT on D−1 day (3 May 1953) indicated the weather would be satisfactory, and the participating experimental groups reported readiness. At the 2200 PDT weather briefing the Weather Officer stated that the predictions of the 0830 meeting would not verify because the ridge which had formed just to the west of NPG had not progressed easterly but instead had remained in a stationary condition; therefore the projected wind velocity at 22,135 ft MSL would be about 50 knots at 360°.

The Air Operations Officer stated that, if the Test Director would permit a bombing run of 330°, he would be willing to accept the required drift to make the HE drop. No cloudiness or other unfavorable conditions were reported, and the Test Manager decided the drop should be made. The Test Director had previously excused the advisors from attending the 2200 weather briefing and advisors' meeting because only an HE drop was involved and no radiation hazard problems existed.

The B-50 aircraft carrying the [redacted] weapon with dummy nuclear core arrived from Kirtland AFB into the NPG area at 2½ hr before scheduled drop time. The IFI was completed at 10,000 ft, and the usual wind runs were made at 333°. On the live run, however, the bombardier found it necessary to call a negative at drop time. As soon as the bomber made its turn away from the target and was on the outside leg of the return bomb run, information was given to the control room that for some reason the bomb did not release. Approximately 15 min later another live run was made and another negative was called for the same reason. The Test Director consulted with the Director, Military Effects Test Group, regarding the desirability of having another live run on the basis of the delayed zero time—whether batteries, equipment, and other technical requirements would stand it. It was decided to try only one more time to drop the device. The run was started and approximately 5 min out, the weaponeer requested permission to use the armed salvo release instead of the normal bombing release for this drop. The Test Director gave permission to use the procedure. By using the armed salvo technique a reasonable part of the electrical circuitry with microswitches on various parts would be eliminated.

Again the bombardier had to call a negative, at which time the Test Director advised the Air Operations Officer to call off the mission. Approximately 5 min later, about 0905 PDT, the sequence timer was operated, sending out time signals starting at −30 sec through zero to the various stations. This was done at the request of the Director, Military Effects Tests. It was also decided there would be no more dry-run rehearsals, and the drop of the live round would be made at 0830 PDT on 7 May 1953.

On the morning of 8 May, following the Effects shot, the Test Director received a report from Kirtland AFB that the difficulty in making the release on the dry run was due to a broken connection in the intervelometer. A complete check-out of the electrical circuitry in the B-50 was made, and all switches and wires were found to be all right. It was with some difficulty that the broken wire in the intervelometer was located.

Following the time-signal run at 0905 PDT on 4 May, a rehearsal of the Rad-Safe and recovery operations was held as prescribed in the Test Director's operational order for this detonation.

5.3.9 Effects (See Sec. 2.1.8)

(a) General Preparations. The Effects shot was scheduled for 7 May 1953, but, as discussed in Sec. b, Meteorology, the weather was unsuitable, and the shot was made on 8 May 1953.

Since this was an airdrop, the weapon assembly crew from Sandia returned to Sandia from NPG to check out the assembly and deliver the unit to the bombing airplane [redacted] The release-tone equipment in the control room was operated during the signal dry runs as well as during the drop by representatives from Sandia, who were also the group responsible for checking out the release-tone transmitters in the bombing airplane. A standard asphalted ground target was used.

(b) Meteorology. On 6 May 1953 at 2200 PDT, a weather briefing and Advisory Panel meeting was held in order to evaluate firing conditions for the scheduled test date, namely, 7 May. The meteorological prognostication was not favorable from two aspects: (1) a $\frac{8}{10}$ alto-

[redacted]

cirrus cloud cover with bottoms at 16,000 ft and tops at 20,000 ft MSL, with the possibility of increasing to as much as $^6/_{10}$ cirrus cover and (2) precipitation in the Salt Lake region. This cloud cover would definitely eliminate some of the more important aircraft participation and quite possibly reduce the sunlight from the east and thereby affect the photography to be made by the 200 cameras scattered throughout the test area. On the basis of surface winds a firing time later than 0830 was looked upon with disfavor. The outlook was definitely unfavorable, and the decision was made to postpone the shot 24 hr.

At the Advisory Panel meeting at 2200 PDT on 7 May 1953, the Weather Officer forecast the winds aloft as shown in Table 5.9, with no precipitation downstream within 500 miles. The skies were to be clear with a possibility of slight cirrus above 30,000 ft. The tropopause was forecast for 45,000 ft, and no low-level inversions were predicted.

Table 5.9—WINDS ALOFT, EFFECTS

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0430 PDT, D-day		Actual winds at shot time, D-day		Actual winds at 1000 PDT, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	230	15					200	15
6,000	250	20	300	17	270	05	220	10
8,000	250	30	300	12	320	10	270	08
10,000	270	40	250	13	260	12	280	10
12,000					250	26	260	18
14,000					260	35	260	24
15,000	270	50	250	45	260	44	250	30
16,000					250	48	240	40
18,000					250	58	240	54
20,000	270	60	250	58	250	57	240	65
25,000	270	80	250	77	250	78	240	72
30,000	270	100	240	103	240	103	240	85
35,000	270	110	240	146	240	170	230	110
40,000	270	120	250	87	240	146	240	110
45,000	270	130					240	100
50,000	270	150						

* These data used by the Weather Officer during the 2200 PDT Advisory Panel meeting.

The nuclear-cloud height was predicted to be 40,000 ft for the forecast winds and 45,000 ft if the winds should be lighter. Fall-out from the top of the cloud was predicted to reach Arizona in 2 hr, with low fall-out at Lake Mead in about 3 hr. The predicted fall-out was in a narrow band with a 12° spread, with levels no higher than 10 mr.

The off-site blast prediction was for a possible focusing on Las Vegas, with no effect at Indian Springs. All test and operational groups were ready, and the decision was made to proceed. However, there was a possibility of canceling after data were received from the microbarographic shots at −2 and −1 hr before detonation time. It developed that these HE shots indicated it was not necessary to cancel the shot.

(c) Detonation. The B-50-D aircraft arrived in the test area at 10,000 ft MSL at 0449 PDT and started the IFI, finishing at 0542. It then climbed to bombing altitude 19,000 ft above terrain and made six wind runs. The bombing direction was 245½° and the true air speed was 250 knots. The [redacted] was dropped (burst) at 0829:55.362 ± 0.002 sec PDT on 8 May 1953. [redacted] The actual burst height was 2423 ft, and the circular error was 837 ft (837 ± 15 ft south and 15 ± 15 ft west of the Frenchman Flat

[redacted]

Ground Zero used for Upshot-Knothole). The nuclear-cloud height was 40,500 ft, and the dust stem which formed did not meet and mix with the nuclear cloud.

The surface winds, as measured at the target area and information transmitted to recorders on the control panel, indicated a situation not suitable for setting off the smoke pots for Project 8.4.

(d) Results. Detailed results of all the projects participating in this shot are given in individual reports in the Upshot-Knothole report series.

Programs 1 to 9. As shown in the participation chart, Appendix A, practically all the projects in Programs 1 to 9 made experiments during the Effects shot. The error in bombing of 837 ft south and, in this case, perpendicular to the blast line caused some loss of data owing not so much to the absolute distance differences but to the angle of attack or orientation effects. It also made interpretation of data for the close in to zero stations somewhat more involved. The fact that the yield of this device [redacted] was slightly less than the anticipated yield was not of prime importance on any of the major experiments in Programs 1 to 9. [redacted]

For the Effects shot the Military Effects Test Group programs consisted primarily of:

1. A basic measurements program involving blast and thermal and nuclear radiation.
2. An extensive military structures and equipment test program.
3. An extensive biomedical effects program.
4. A study of the effects on aircraft in flight, involving drones and B-50 and B-36 manned aircraft, to determine the effects of blast and gust loading.
5. An extensive program of the evaluation of radiac instruments and tests associated with Indirect Bomb Damage Assessment such as determinations of yield and burst positions.
6. A series of long-range detection (LRD) tests.
7. Thermal effects on materiel by the exposure of test panels and the characteristics for primary fire ignition for both urban and rural areas. Also included in this program was the evaluation of service uniforms for protection, using pigs as subjects.

The blast measurements were made at the ground surface, near the ground surface, at heights of delivery aircraft, and for "free air" by means of the rocket-trail technique. The measurements provided complete data for obtaining the path of the triple point and the formation and evaluation of the Mach reflection. The thermal- and nuclear-radiation measurements were made principally near the ground. The results of the basic measurements were in substantial agreement with current military doctrine and were of such a nature as to confirm previous test data. As so far reported (see Report UKP-72) there were no examples of new phenomena discovery.

The structures and equipment used for the tests were of the nature of being idealized and prototype. The major items consisted of:

1. Six complete field hospitals located at approximately 4160, 9000, and 15,000 ft from the burst position.
2. Full-scale sections of several bridge types.
3. A forestry stand of 145 ponderosa pines.
4. Numerous wall and roof sections located at several distances from the burst position.
5. Representative POL installations of the Air Force, Army, and Marine Corps.
6. Precast Navy warehouses.
7. Underground structures of interest to the Corps of Engineers.
8. Numerous idealized concrete structures and cubicles for determining blast-loading characteristics.
9. Complete aircraft and many aircraft elements arranged for specific test purposes.
10. Military equipment consisting primarily of jeeps and trucks, Marine Corps landing vehicles, and Signal Corps equipment and installations.

The drone-plane operation in connection with Project 4.1 was very satisfactory. On the first pass both USAF QF-80 drones missed the top of the cloud but were returned by their

[redacted]

mothers for a second penetration, and successful passes were made. These drones were instrumented to measure gamma radiation and carried two monkeys. They flew at 30,000 and 32,000 ft at approximately 6 min after detonation. These tests showed that personnel in pressurized aircraft passing at 400 knots through a 30-Kt nuclear cloud at least 4 min old would receive an external dosage of less than 50 r, with negligible respiratory hazard.

Project 8.4 (attenuation of thermal radiation) involving the use of a battery of smoke generators was not carried to completion owing to the possible interference of the smoke screen with the bombing procedure. The smoke generators were to be started at approximately 5 min before drop time if the surface-wind pattern gave assurance that the target would not be obliterated in the event the bombardier "negatived" the first live run. A reduced version of this project test was, however, completed during the Gun shot.

The results of all the tests involved in a test program of this magnitude can be properly evaluated only after considerable study. The results obtained from the Effects shot must also be compared with those of similar tests conducted on the Gun shot at a lower burst height. Preliminary conclusions are drawn in Report UKP-72 and in the preliminary reports prepared by the individual projects.*

Programs 10 to 20. [redacted]

Programs 21 to 29. Programs 21 to 24 and 29 participated in this shot. In addition, experiments were made on the two FCDA partitioned structures as part of Project 3.29. In fact, these FCDA structures tests were one of the major efforts of the Civil Effects Test Group for this shot. All the projects participating reported satisfactory results, although some types of air zero locators tested as part of Project 21.3 failed to function as expected.

A large part of the tests conducted during the Effects shot require considerable analysis of the data before conclusive results can be drawn.

(e) On- and Off-site Fall-out. The radiological problems encountered in this shot were only minor. No contamination was found outside the test area, and the highest level on-site at ½ hr after the detonation was 360 mr at Ground Zero. The approximate radius of the 100-mr line was 500 yd and of the 10-mr line, 1200 yd. The ground contamination was centered south of Ground Zero, indicative of the bombing error. By 1300 PDT on shot day the Ground Zero level had dropped to 110 mr, and by the following morning the level was 10 mr, and Rad-Safe controls were lifted for the Frenchman Flat area.

(f) Other Details of the Shot. No off-site blast damage was reported from this shot, although there was minor damage found in some of the buildings at Camp Mercury.

Desert Rock V Exercises. There were 2149 troops from the 1st, 3rd, and 4th Army areas and 879 troop observers involved in the maneuvers. Because of Air Force and Office, Chief

*The Military Effects preliminary reports are listed in Report TID-9004 (Special Supplement), August 1953, Joint Weapons Tests Reports Committee.

[redacted]

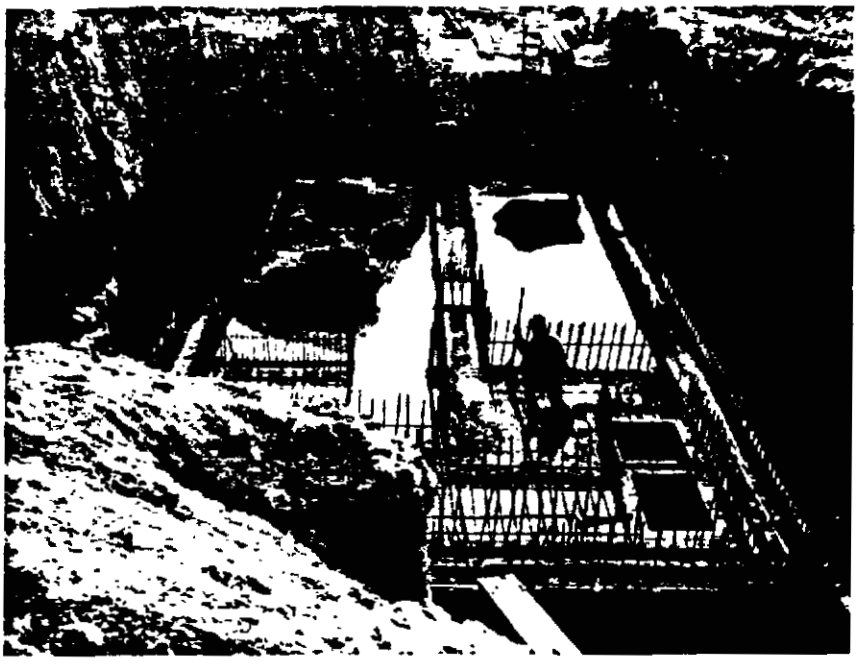


Fig. 5.48—Base of the alpha-recording shelter, Frenchman Flat. The shelter was under construction prior to Effects shot.

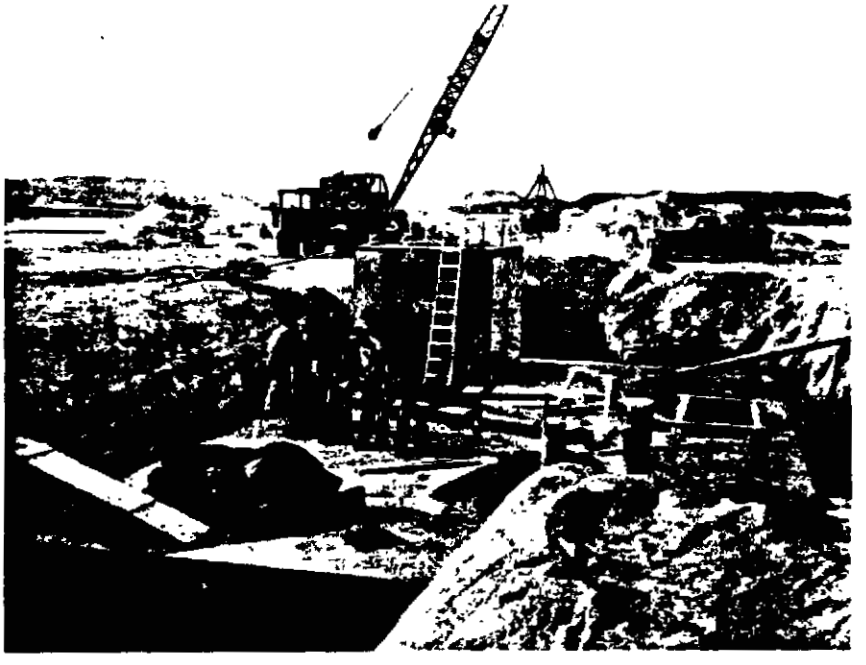


Fig. 5.49—Alpha-recording shelter practically finished, Frenchman Flat.

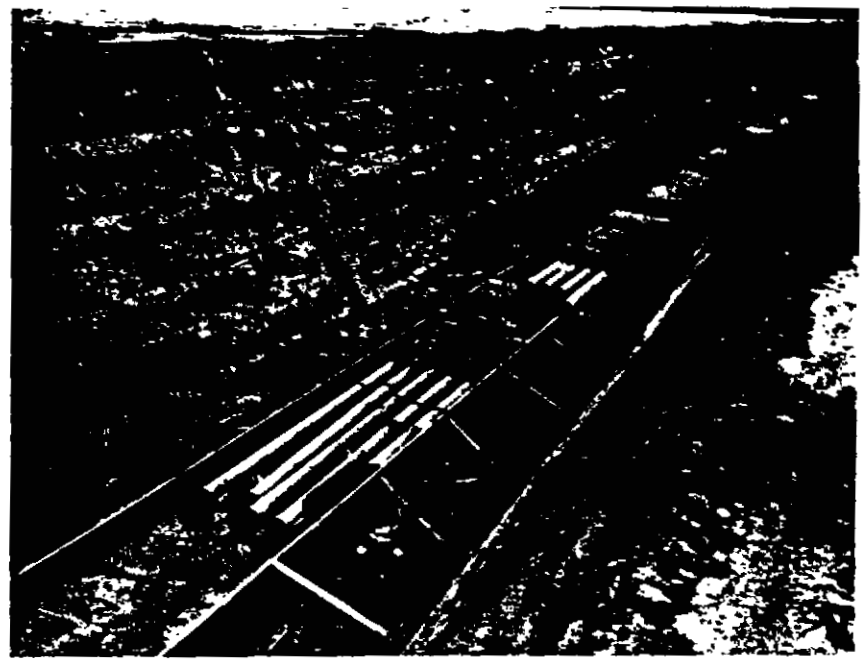


Fig. 5.50—Transite pipe installation, Frenchman Flat. The pipe was used for housing 3-in. coaxial lines. Pipes are 15 ft below ground for gamma shielding.

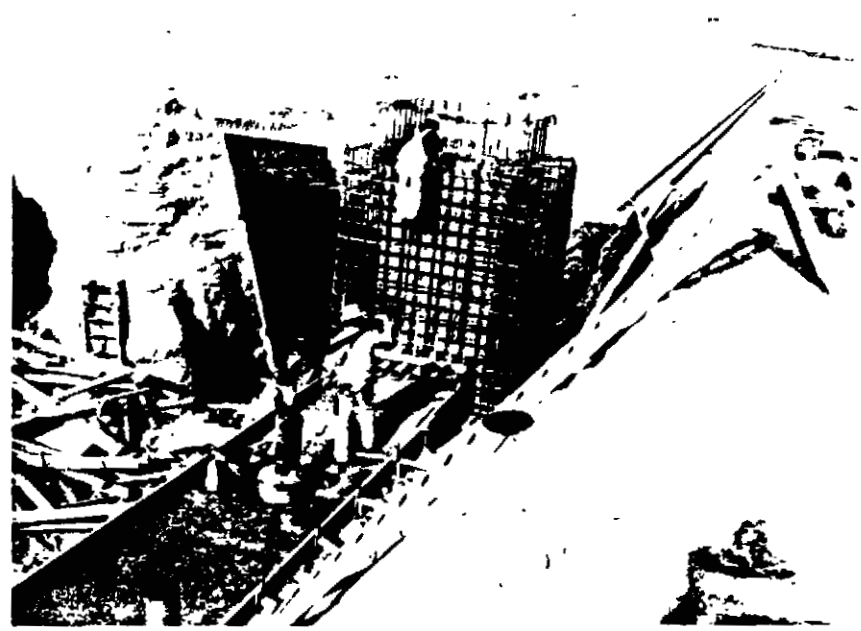


Fig. 5.51—Alpha-detector station along coax line, Frenchman Flat.



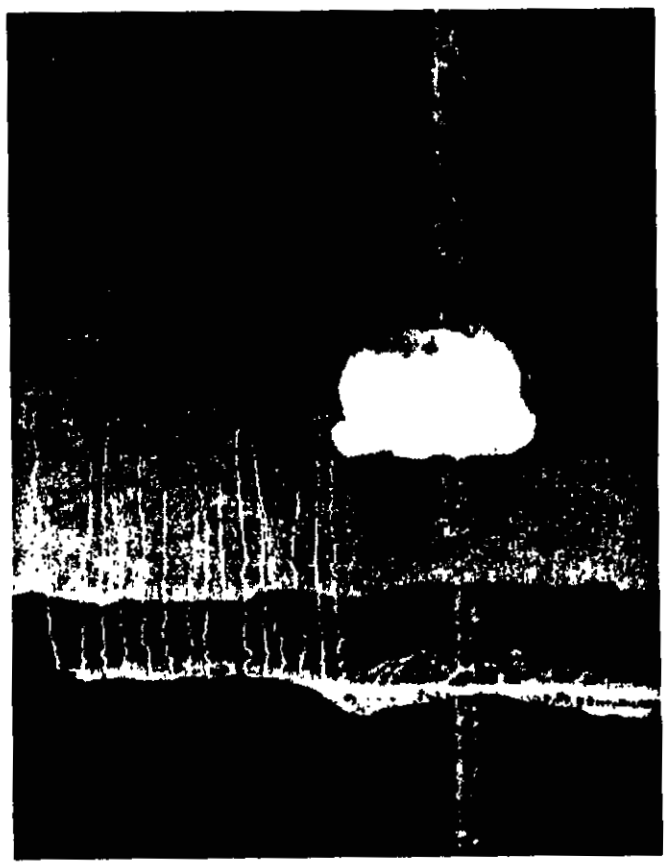


Fig. 5.52—Effects shot before formation of dust stem.

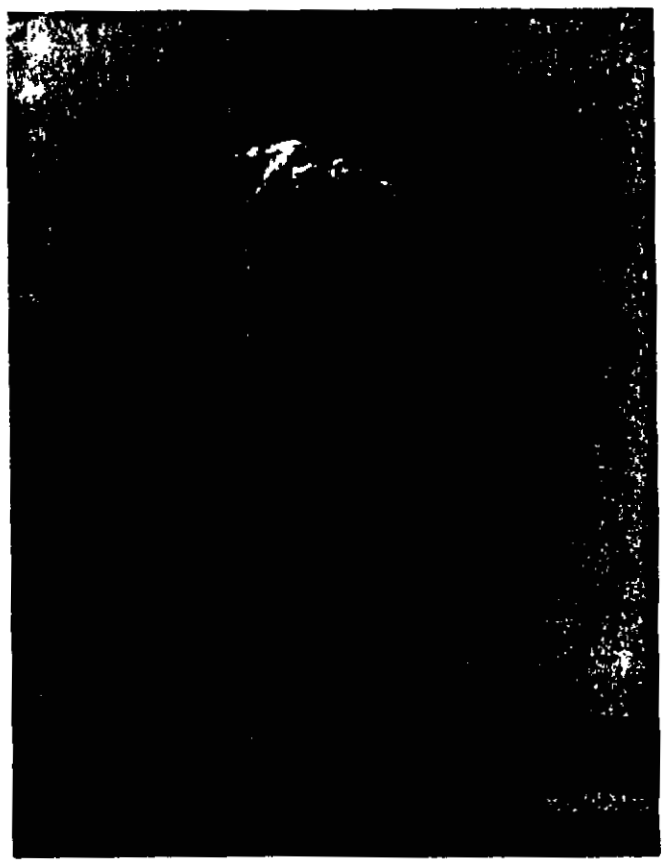


Fig. 5.53—Effects shot, showing dust stem rising from ground.



Fig. 5.54—Late cloud picture of Effects shot. Dust stem did not mix with nuclear debris.

[redacted]

Army Field Forces (OCAFF) restrictions, troops and troop observers were entrenched 9800 yd southwest of Ground Zero at shot time. The tactical maneuver included the use of seven Army helicopters (H-19's) of the 506th Transportation Helicopter Company which airlifted two platoons of infantry from trenches to an objective 1500 yd southeast of zero. The Marine helicopter detachment also participated.

Observers. Fifteen congressmen attended this detonation, along with twenty-eight official observers who were executives of various aircraft industries. Approximately 100 operational and test aircraft were involved in this shot.

5.3.10 [redacted] See Sec. 2.1.9)

Immediately after th[redacted]shot, it was obvious from the heavy fall-out in Area 3a that completion of the tower and instrumentation required [redacted] would necessitate a delay in the then existing firing date of 2 May, and a date of 16 May was scheduled. However, at the 0900 PDT weather briefing on 15 May the situation appeared very improbable for firing, and the Test Director arranged for a weather meeting with the Test Manager at 1300 PDT on 15 May.

At 1300 on 15 May postponement was made official, and the next look at the weather was scheduled for 16 May at 1300. The unfavorable meteorological conditions persisted at the 16 May weather meeting, but improvement was forecast; therefore another 24-hr postponement was announced. The conditions persisted on 17 May, and again a 24-hr delay was taken. Another weather meeting was held at 1300 on 18 May. With an improved weather situation, arrangements were made to fire on the morning of 19 May, and the execute order was issued. These postponements i[redacted]made it necessary to change the dates of the Gun and Climax shots to 24 May and 1 June, respectively, and all concerned were advised on 16 May.

(a) General Preparations. LASL Group W-5, responsible for installation of [redacted] equipment in the tower at Area 3a, required one week to ten days prior to the shot. The ground contamination level at the tower base after the [redacted]shot was 1.5 r. Ground decontamination was started by the Field Manager's contractors on 7 May when the level was 170 mr, and by 10 May the level around the tower and in the tower cab had been reduced by decontamination operations to approximately 20 mr, although there were spots which gave higher readings. Decontamination was accomplished by removing the top layer of ground and placing it approximately 100 ft from the tower base.

Under these conditions the [redacted] gear were installed and tested prior to shot time. In addition, the NRL group (Program 18) had erected for their use a 300-ft radio type tower 400 ft east of the main device tower. Three HE argon flash lamps were placed on this radio tower, and the area around the tower was decontaminated.

On 15 May at 1530 the [redacted] without nuclear parts was placed in the tower cab and between 1700 and 2300 on this date small test shots were made on the NRL tower [redacted]

(b) Meteorology. At the 2200 PDT weather briefing and Advisory Panel meeting on 18 May, the Weather Officer forecast the winds aloft as shown in Table 5.10. Along with the winds, a $^{9}/_{10}$ cirrus cloud covering at about 25,000 ft was forecast, on the basis of a fairly large moisture content in the air at that level. A fall-out pattern similar to that of the [redacted]shot but shifted slightly northward was forecast, with very probably a fall-out on Glendale (population 15), Overton (population 600), Logandale (population 350), and Riverside (population 14). Thus far in the Upshot-Knothole series Glendale, Overton, and Logandale had received no fall-out, but Riverside already had received as much as they should have for this period. The meteorologi-

[redacted]

cal experts stated that there was a 50 per cent likelihood of at least a 10° shift in wind direction. Besides the somewhat unfavorable off-site fall-out picture, there was also the problem of cloud sampling with the $^{5}/_{10}$ cirrus cover predicted. The Air Operations Officer proposed to send a scout plane aloft at 0230 on D-day. If the cirrus at that time was well below the estimated cloud height of 42,000 ft, the chances of getting samples were not too remote. With this somewhat dubious outlook the Test Manager decided to proceed with the shot but to watch

Table 5.10—WINDS ALOFT, [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0200 PDT, D-day		Actual winds at shot time, D-day		Actual winds at 0800 PDT, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	220	5			020	5	Calm	
6,000	200	15	210	17	200	20	200	17
8,000	230	15	220	20	200	26	200	21
10,000	270	15	230	15	210	18	220	17
12,000					200	15	220	20
14,000					220	17	260	26
15,000	280	20	260	14	230	21	270	32
16,000					260	30	280	36
18,000					270	37	280	37
20,000	280	30	270	27	280	38	270	39
25,000	290	40	300	24	280	54	270	53
30,000	300	50	300	43	290	60	280	60
35,000	300	65	310	55	290	65	280	78
40,000	310	75	300	51	300	67	280	70

* These data used by the Weather Officer during the 2200 PDT Advisory Panel meeting.

closely the meteorological observations as they were collected during the remainder of the night.

(c) Detonation. The [redacted] device was detonated on a 300-ft 30-ton aluminum tower in Area 3a, Yucca Flat, at 0504:59.530 ± 0.005 sec PDT on 19 May 1953. The timing system functioned in a completely normal fashion. [redacted]

The nuclear-cloud height was 44,000 ft, and the sky was overcast at 25,000 ft, with scattered clouds at 18,000 ft. There was no off-site blast damage reported, although the blast was heard at Indian Springs and Las Vegas, Nev., and Bishop, Calif. Bishop reported hearing 12 or 13 distinct shocks.

(d) Results. For final results reference should be made to the individual program and project reports which are a part of the Upshot-Knothole report series.

Programs 1 to 9. A few projects in each of the Programs 1 to 9 participated on this shot. Self-recording mechanical blast gages were tested in anticipation of their use in future nuclear-test programs.

One Navy drone from Project 5.1 completed a successful mission, although the $^{9}/_{10}$ cloud cover may have affected the thermal measurements.

In Program 7, which required nuclear-cloud samples, poor samples were obtained because the sampler control aircraft lost the nuclear cloud owing to the excessive cloud cover.

Programs 10 to 20. [redacted]

[redacted]

[redacted]

Programs 21 to 29. Programs 22 to 24 and 29 participated on this shot. Personnel of Project 22.4 (drug-irradiation studies) placed boxes of drugs at distances from 400 to 2500 yd from the detonation in various arrays. All boxes were recovered after the shot, and neutron-induced activities were measured.

Programs 23 and 24 studies consisted primarily in making further studies of the effectiveness of the underground communal shelters. Dogs and mice were used to determine the biological effects due to radiation and blast produced by the detonation, and mechanical pressure and deformation gages measured the structure motions. The animals were placed at various locations inside the shelters and in the entranceways. Early recovery was made after the shot, and the tests were successful.

In Program 29 chemical and film dosimeters were located at distances of 1300 to 2400 yd from zero. Recovery of these dosimeters was successfully made, but neutron detectors placed along a line running west of zero were not recoverable on D-day owing to the excessive fall-out in that area. The instruments were recovered the following day, however.

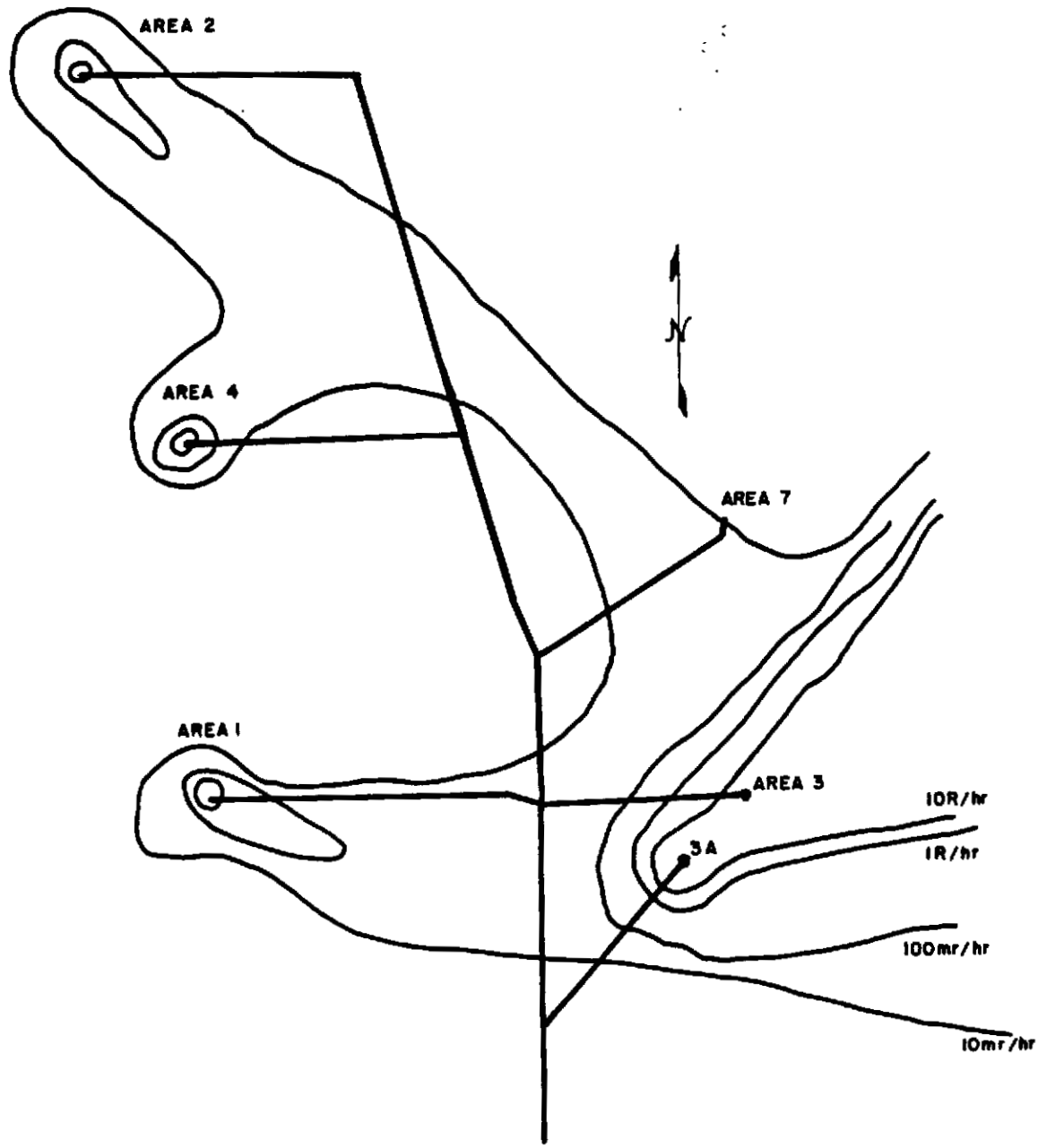
(e) On- and Off-site Fall-out. The Yucca Flat area was already quite contaminated in all shot areas before the Hamlet shot. No difficulty was encountered in the initial survey after the detonation. The Yucca Flat Rad-Safe situation 1 hr after the shot is shown in Fig. 5.55. The principal instrumentation was south and west of the zero point in Area 3a, and no difficulties were encountered in making recoveries. Area 7-3, the site chosen for the Climax airdrop, was in a heavy fall-out region, but, since the instrumentation for that shot was to be minimal, no major difficulties were foreseen.

As seen from the winds aloft, Table 5.10, a shift in the wind pattern resulted in off-site fall-out which included the most heavily populated region east of the proving grounds. The off-site fall-out pattern is shown in Fig. 5.56. The doses shown are a 70-year integration and are based on: (1) a person's being outside the full 24 hr of a day, (2) the decay law following the $t^{-1.2}$ relation, (3) no weathering, and (4), in general, the very maximum dosage-producing conditions. The subject of realistic dosages produced by such fall-out is being further pursued, and, although conclusive measurements were not made during Operation Upshot-Knothole, such a study will be carried out in future tests.

As may be seen from the off-site map, fall-out occurred across several of the main highways in northeastern Nevada and southern Utah, with the highest levels being recorded on U.S. Highway 93 between Glendale and Alamo. It was again necessary to institute precautionary measures, and road blocks and warnings to residents were established. The 1-r infinity dose line extended as far as 250 miles east of Ground Zero, with the average width of the area of the 1-r line being 50 miles.

The complete documentation of the activities of the off-site Rad-Safe fall-out group, along with the Field Manager's assistance in handling the problems connected with the road blocks, vehicle decontamination, and various incidents in connection with "concerned" personnel in the fall-out area, is contained in the Rad-Safe Report in the Upshot-Knothole report series.

[redacted]



DETONATION TIME 0505 PST 19 MAY 53
SURVEY TIME, 0600 PST 19 MAY 53

Fig. 5.55—Radiological situation, Yucca Flat, [redacted]

[redacted]

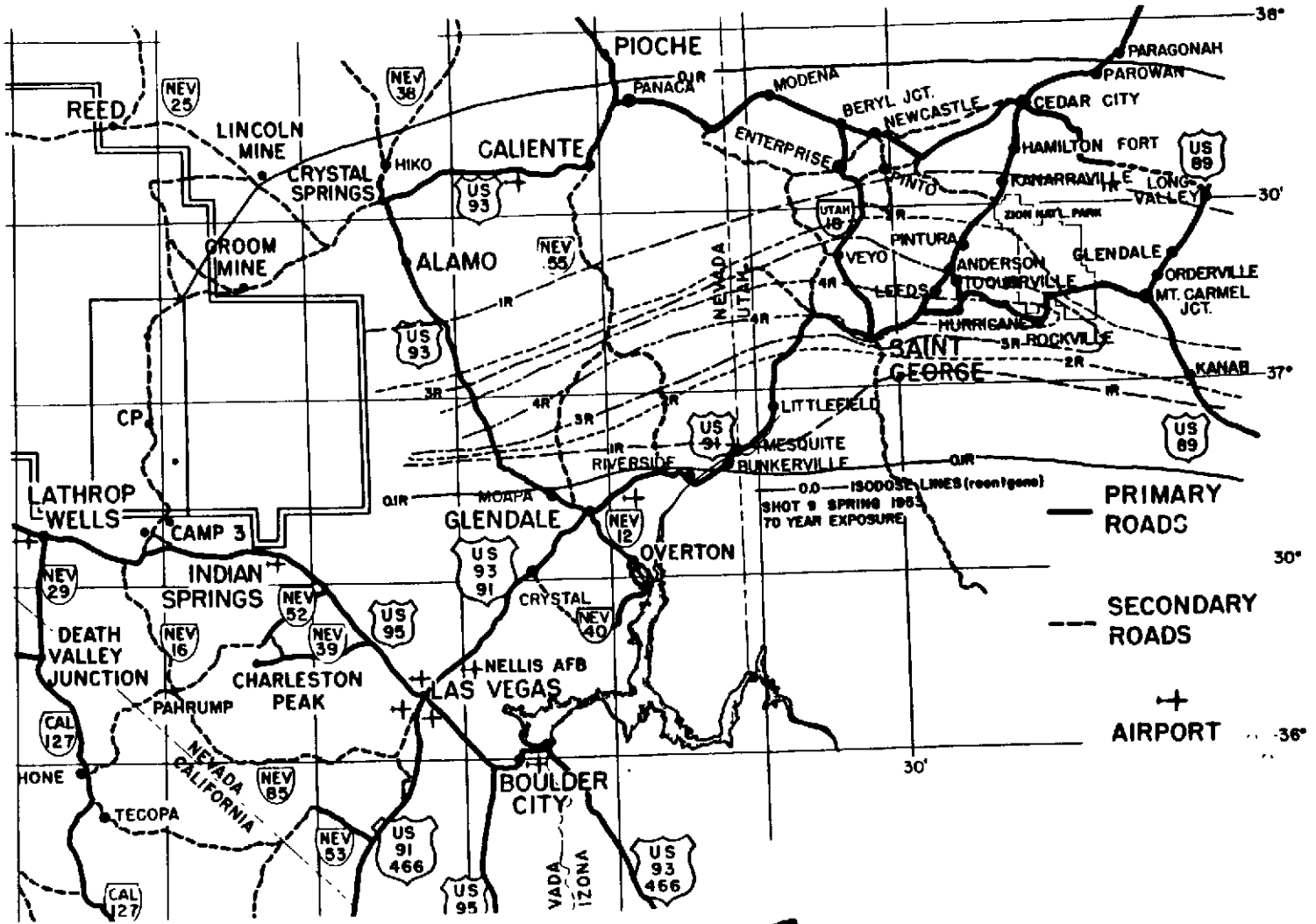


Fig. 5.56—Off-site fall-out from [redacted] detonation.

Approximately 125 vehicles were washed in St. George, Alamo, and Las Vegas, and the numerous reports of personnel suspecting radiation sickness or effects were promptly investigated. Monitors remained in the St. George area for several days in order to continue measurements and investigate various reports. Considerable concern was voiced by personnel at Kanab, Utah, after uranium miners nearby reported excessive dosimeter readings. These reports were investigated by staff members of the Test Director's organization. The fall-out in southern Utah from th[redacted]shot was sufficiently intense to require that considerable attention be given to the conditions under which the last two scheduled shots in Operation Upshot-Knothole were made.

(f) Other Details of the Shot. A total of 37 congressmen arrived on 16 May to witness the detonation, but, owing to the three-day weather delay, only 23 remained to see the shot.

There was no formal troop maneuver in the Desert Rock V exercise for this shot, but 377 troop observers and 326 Desert Rock troops were entrenched 4000 yd southeast of Ground Zero at shot time. The Marine helicopter detachment also operated successfully during this shot, and this operation concluded their participation in the test series.

5.3.11 Gun (See Sec. 2.1.10)

The Gun shot was originally scheduled for 21 May, but, owing to the change in over-all schedule after th[redacted]shot, the Gun was rescheduled for 23 May. However, as pointed out in Sec. 5.3.10, the three-day weather delay for [redacted]made it again necessary to reschedule the Gun to 25 May.

On 10 October 1952 the full-scale test for the atomic shell was approved by the Joint Chiefs of Staff. In this test it was intended to:

1. Determine that the atomic shell would function as intended.
2. Obtain a reasonable measure of effectiveness of the atomic shell.
3. Train selected Army personnel in the handling and the firing of the atomic shell.
4. Test the stockpile-to-target sequence.
5. Determine whether the shell would survive normal shipping and handling procedures.
6. Determine if all the details of security plans were necessary and sufficient.
7. Determine whether the ballistic difference between shell, HE spotting, 280 mm, T-123 and shell, atomic explosive, 280 mm, Mk-9 could be reconciled by computation.

The test was divided into four phases. Phase 1 was a check of the regulations and procedures incident to the delivery of weapons from the stockpile site to the Army Ordnance support unit and a further check of the survival of the components in the delivery process. Shipments of components to Ft. Sill and to NPG tested this phase. Phase 2 was the development of gunnery techniques for the delivery of the atomic shell, the comprehensive testing of the tactical doctrines involved in the employment of the 280-mm gun, and the firing of an atomic shell at NPG. This phase was further divided into three parts: (1) preliminary firing at Ft. Sill for the test of gunnery and counterintelligence techniques in March and April 1953; (2) the test of tactics of the 280-mm gun unit to include tactical movement, occupation of position and preparation for firing (this portion was to be accomplished at Ft. Sill and/or NPG or enroute to and from NPG); and (3) the proof firing of the atomic shell with active nuclear components at NPG in conjunction with the Upshot-Knothole series. Phase 3 was the obtaining of basic data directly applicable to the atomic shell. The preparation of reports on this phase was determined by OCAFF and AFSWP. Included in the report would be information relative to blast pressure vs distance and time, thermal intensities vs distance, gamma and neutron intensities vs distance, and gross effects on selected targets. Measurements on the shell performance (yield, time of flight, and component behavior) were also made. Phase 4 was concerned with the roll-up and preparation of reports.

It was at Ft. Sill, and later at NPG, that the four delivery techniques were tested. In the conventional high-burst registration method, six rounds are fired with metro corrections applied and all directed toward a predetermined target location. A mean point of burst (direction, range, and height) for the six rounds is computed. The correction necessary to shift from the

computed mean point of burst to the desired point of burst is applied to the next round and results in effective fire on the predetermined target. The spotting-round adjustment, although actually not utilized as a separate delivery method, consisted in computing data derived from the use of one round rather than six as in the preceding method. In the muzzle velocity error plus metro correction technique, the firing table for the 280-mm gun is used and corrections for metro and variations from normal in muzzle velocity are made based upon data recorded from previous firing by the particular weapon being fired. In the silent adjustment the fuze of the round is set to prevent detonation, and the round falls inert in enemy territory. Radars track this round and provide data from which corrections are computed and immediately applied to the following atomic round. Although all techniques were used, excessive radar clutter at NPG precluded the successful testing of the silent-adjustment technique.

The firing at Ft. Sill was conducted on 19 and 26 March, and on 2 and 9 April. The firing process consisted of a six-round high burst, a silent round, and a verifying round.

The two 280-mm guns arrived at Nellis AFB on 3 May and at NPG on 9 May. On 7 May the Artillery Test Unit (ATU) personnel closed in at Camp Desert Rock. Although stationed at Camp Desert Rock for administrative and logistical support, the ATU operated as a part of the organization of the Test Director. Included in the ATU organization were the following:

Unit	Officers	WO	EM	Civ	Total
52nd FA Group	4	0	1	0	5
867th FA Bn.	9	2	142	2	155
136th OSWDS Co.	7	0	10	0	17
The Artillery School	19	1	5	7	32
653rd FA Observ. Bn.	2	2	52	0	56
Totals	41	5	210	9	265

It is well to note that, although the operational period at NPG truly began on 7 May, preceding advance groups ran surveys in the forward area for the various units of the firing battery and coordinated and arranged procedure and policy for the NPG phase of the 280-mm gun test.

Figure 5.57 is a schematic diagram of the ATU installation for the test firing at NPG. Indicated in the diagram are the gun position, the gun-target line (10,956 yd), radars No. 1 and No. 2 (AN/MPQ 22) and radars No. 3, 4, and 5 (AN/MPQ 10), the flash-spotting observation posts, the fire-direction center, camera position, and the metro station. The radars endeavored to track each shell to its burst point, including the atomic projectile [redacted]Mk-9.[redacted] The fire-direction center was the battery section which calculated all firing data and from which battery control was exercised. The metro station, which was comparable to the NPG Rawinsonde section and which was located just to the right and rear of the fire-direction center, provided hourly ballistic information for use in the determination of gunnery data. The Mitchell camera station, originally located about 3000 yd southeast of Ground Zero, was later changed to the fire-direction center area. By means of an electric clock and the high-speed camera unit, it was possible to record the time-of-flight of the projectile from the gun to the burst point. Also included in the installations of the ATU were the mobile units of the 136th Ordnance Special Weapons Direct Support Company (OSWDS), which supported the gun battery in the preparation of operational suitability test (OST) rounds and the atomic projectile [redacted]Mk-9,[redacted] and which recovered all vital components of OST rounds after firing

(a) General Preparations. Launching the [redacted]Mk-9[redacted] device from the 280-mm cannon introduced a few operational problems to the test organization, primarily because every effort was made to conduct the strictly scientific tests of the [redacted]Mk-9[redacted] weapon and yet allow as much as possible of the tactical exercise and operational studies on the part of the ATU. Two meetings were held early in 1953 between representatives of the ATU, the DWET, and the Test Director's office to arrange for the operation at NPG. In order to measure alpha from a ground installation, a burst height of 500 ± 100 ft was considered necessary, along with a burst along the trajectory of ±150 ft from computed zero position. The error in burst along the trajectory enters from

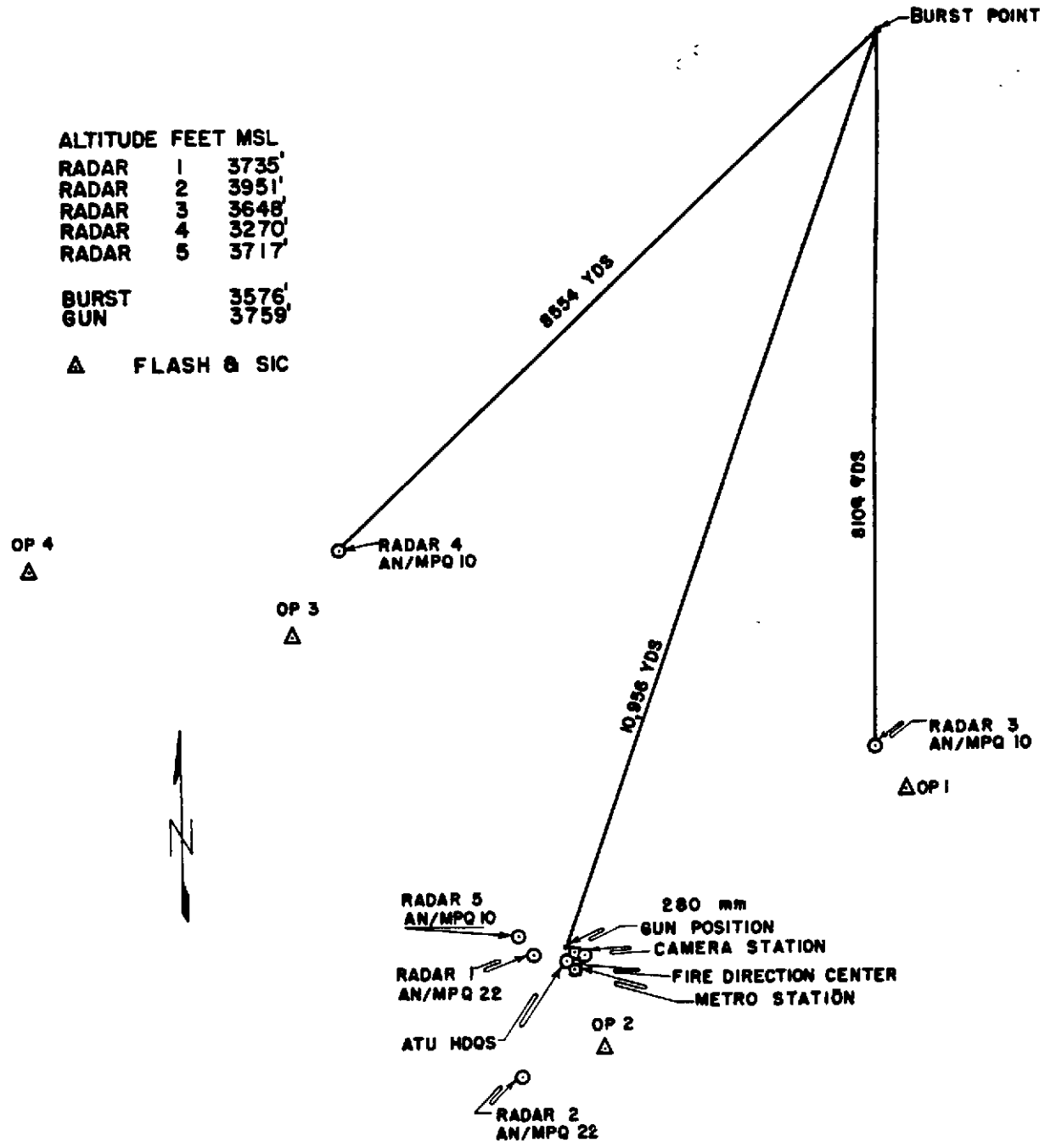


Fig. 5.57—Schematic of ATU installations at Frenchman Flat.

the inaccuracies involved in the time-fuze action. Representatives of the ATU stated an accuracy of ±30 yd could be assured. Weapons effects tests involving blast and thermal effects were to be included in the test program, and the above limits of error in burst position were considered satisfactory.

Besides the agreements concerning burst position, the Test Director considered it necessary to fire the launching cannon from the sequence timer at the control point. This method of firing would simplify the firing circuitry and assure the correct timing of other technical equipment used for making measurements of the detonation, such as high-speed photography, alpha, blast, thermal, and other equipment requiring critical timing. The ATU agreed to this request. Two other major items regarding the firing operations were discussed. The first was a desire on the part of both the Test Manager and the Test Director that all personnel at the 280-mm gun position at firing time be in slit trenches or behind a barricade in order to protect them against blast and flash in the event of a misbehavior of the Mk-9 device. [redacted] The second item was a desire on the part of the Test Director to fire a Mk-9 device which had been thoroughly inspected by Sandia personnel (for mechanical parts) and LASL personnel (for nuclear parts) since this group had been responsible for developing the device. It was also the desire of the Test Director that this projectile, after inspection, should not be used for any of the tactical maneuvers proposed by the ATU. Both requests of the Test Director were agreed to.

As is usual for all detonations made at NPG, an emergency plan was developed by the Test Director's staff to be used in the event of a malfunction of the Mk-9 during firing operations. It was understood that the firing operations were under the direction of the Test Director. It should be pointed out that, except for the few restrictions enumerated in the previous paragraph, every effort was made by the Test Director to conduct the test according to the desires of the ATU. This group was very cooperative, indeed, and it is believed the success of the test was due in a large part to this cooperation.

(b) Meteorology. At the 2200 PDT weather briefing and Advisory Panel meeting on 24 May, the Weather Officer forecast the winds aloft for shot time as shown in Table 5.11. No precipitation downstream for 1000 miles and no clouds were predicted. The tropopause would be at 40,000 ft. Fall-out, calculated on the basis of a similar device on a 300-ft tower, would be somewhat higher than it was desired to tolerate on the basis of the off-site fall-out that had already taken place during the Upshot-Knothole series. However, the particle size from Frenchman Flat and the 500-ft burst height made it seem quite unlikely that levels higher than 10 mr would occur in off-site fall-out. The off-site blast prediction was for a possible damaging blast effect in the vicinity of Caliente, Nev., but nowhere else. The advisors recommended that the shot be fired.

(c) Detonation. Preliminary firing was conducted at NPG on 15, 22, and 23 May. The firing of the 280-mm Mk-9 atomic shell was accomplished on 25 May 1953. The firing phase was as follows:

	Gun 1		Gun 2	
Date	Rounds	Type	Rounds	Type
15 May 1953	5	T-122	4	T-123
	6	T-123		
	1	Mk-9 OST		
22 May 1953	7	T-123		
	1	Mk-9 OST		
23 May 1953			15	T-123 E1
			7	T-123
25 May 1953	7	T-123		
	1	Mk-9		
		102		

[redacted]

The T-122 rounds were initially used as shot-day warm-up rounds but were discontinued after 15 May on the advice of Aberdeen Proving Ground technicians. These rounds were HE shells using a charge 3. The T-123 type shell, on the other hand, was a spotting round, and a normal charge was used for the NPG firing. The accuracy of the location of burst for the Mk-[redacted] operational-suitability test rounds was as follows: (1) 15 May 1953: azimuth, zero; range, +134 yd; height, –49 ft; (2) 22 May 1953: azimuth, left 8.8 yd; range, +76 yd; height, –32 ft. The Mk-[redacted] atomic shell was fired with a normal charge from Gun 1 at a range of 10,956 yd at 0830:00.332 ± 0.002 sec PDT (burst time) on 25 May 1953. Time-of-flight from the closure of the firing relay to the time of burst as determined by the photocell and official method was 18.65 ± 0.01 sec. The time of flight by the film method, accomplished with a high-speed Mitchell camera by ATU personnel, was 18.67 sec. The range error was –159 ft, the deflection error was 36 ft left, and the height-of-burst error was +24 ft. This corresponds to an error from zero of 139 ft south, 86 ft west or a circular error of 164 ft. Although three fuze misfires occurred in the preliminary test firings of 15 May, no difficulties were encountered during the 24 May operation. The nuclear-cloud height was 34,800 ft. Figure 5.58 is a photograph of the Gun detonation over Frenchman Flat.

Table 5.11—WINDS ALOFT, GUN

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0200 PDT, D-day		Actual winds at shot time, D-day		Actual winds at 1100 PDT, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface							180	18
6,000	180	08	160	24	190	21	190	19
8,000	200	15	200	36	190	21	190	27
10,000	220	20	210	37	200	30	190	27
12,000					200	31	190	30
14,000					200	33	190	41
15,000	230	35	240	43	200	35	190	44
16,000					200	48	190	47
18,000					210	74	220	67
20,000	230	60	230	82	220	74	220	77
25,000	230	70	230	98	220	65	210	96
30,000	240	80	230	104	220	85	210	98
35,000	240	80	230	113	220	120	210	93
40,000	240	50						
45,000	240	30						

* These data used by the Weather Officer during the 2200 PDT Advisory Panel meeting.

(d) Results. Complete information on the results of the various projects participating in the Gun shot are contained in the individual project reports forming part of the Upshot-Knothole report series.

Programs 1 to 9. All programs in the Military Effects Test Group participated in this shot. The installations used for the Effects shot were made with a view in mind of also using them for the Gun shot. Several new installations were added, such as a comprehensive display of railroad equipment, and it was possible to use the smoke generators for the thermal experiments in Project 8.4. The basic measurements conducted on the Effects shot were repeated on the Gun shot. Many of the structures used on the Effects shot were also used. As expected, more neutrons escaped from the detonation of the Gun device, and for measurements in this field the biomedical group utilized small animals.

[redacted]



Fig. 6.58—Detonation of [Mk-9] device, Frenchman Flat.

The Director, Military Effects Test Group, states in Report UKP-72:

> Perhaps the most significant outcome of this test program was the clear demonstration of the excessive damage effects in the precursor blast region peculiar to the low burst height used for the second Knothole shot. On the target types exposed, almost total destruction was obtained on some targets to a radius of ½ mile, generally greatly exceeding predictions. It is evident that peak pressure alone is not a satisfactory damage criterion for all project target types. For targets exposed to approximately the same maximum pressures on the two Knothole tests the damage inflicted by the second shot was markedly greater for some target types than that obtained from the high burst weapon. On the other hand, for a target of a different type (a concrete warehouse, presumed to be sensitive to pressure) exposed to the same maximum pressure on both shots, the damage produced in the precursor region by the second shot was slightly less than that obtained from the high burst weapon. It is probable that the precursor effects may lead to a reconsideration of the relation between peak pressure and the effects of a blast wave on targets, with particular emphasis on targets susceptible to drag or wind forces. Preliminary results indicate that the dynamic pressure (which determines drag or wind forces) is appreciably greater for a given side-on pressure in the precursor region than it is for a corresponding side-on pressure in a conventional blast wave. The latter relation had previously been used to estimate drag or wind forces at specified pressure levels. The extreme turbulence, the irregular pressure-time relations, and the general characteristic of long time duration of nearly constant pressure may also contribute to the unusually high damage obtained. Only after the careful consideration of the many detailed measurements and target evaluations can a further clarification of these effects be anticipated.
>
> While these damage effects were observed in precursor regions it does not follow that attack conditions should be chosen to maximize precursor formation; such effects may be characteristic of any low burst, without regard to precursor phenomena.

The above statement is based on opinions formed a few weeks after the completion of the test program. No consideration had been given to the effects of dust loading, Mach reflection, and equivalent blast-wave effects at the same distances from an explosion where surface conditions were not favorable for the generation of a precursor. In particular for low burst heights it is not yet known whether the precursor enhances damage effects or not. There are no experimental data to support a conclusion in either direction at this time.

Programs 10 to 20. [redacted]

Programs 21 to 29. Programs 23, 24, 26, and 29 participated in this shot. In addition to the biological and plant material exposed during this test, two school buses and two passenger vehicles were located 3100 ft from zero. These vehicles all received heavy physical damage from both blast and thermal effects. Cameras were directed at the vehicles, and very satisfactory photographs were obtained of vehicle motion during the detonation.

(e) On- and Off-site Fall-out. The Gun shot, approximately 15 Kt and detonated 524 ft above terrain, produced a nuclear cloud which went 34,800 ft high as reported by the sampler aircraft and a dust stem which met and mixed with the cloud at low altitudes. The winds at the high levels were measured to be over 100 knots, and this carried the cloud out of the area very rapidly. The cloud had moved over Salt Lake City by 1200 PDT. No fall-out was detected in either Salt Lake City or Ogden, and the maximum fall-out detected was 7 mr/hr at Lincoln Mine.

The ground levels approximately 1 hr after detonation are shown in Fig. 5.59. The close-in to zero levels of 10 r/hr restricted recovery operations in that area during the first day.

As stated above, no detectable fall-out above 7 mr/hr was noted from this shot. Minor concentrations in the air sampling data were noted in Crystal Springs, Caliente, Panaca, Pioche, and Milford.

[redacted]

(f) Other Details of the Shot. In addition to the 60 congressmen, the Secretary of Defense, AEC Commissioners, the Secretary of the Army, the Chairman of the Joint Chiefs of Staff, and other personnel from the departments of State and Defense witnessed the Gun shot. These people were located at an observation point approximately 8 miles west of the burst position but in clear sight of the 280-mm cannon.

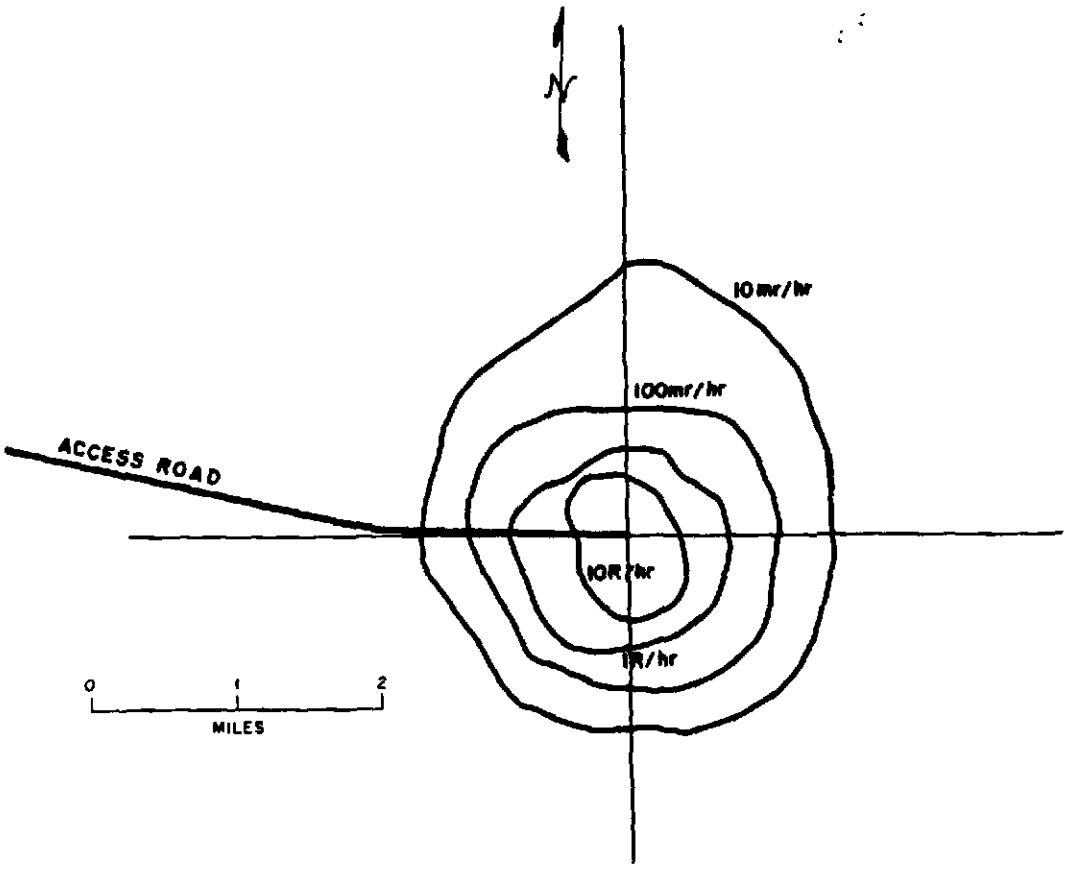


Fig. 5.59—Radiological situation, Frenchman Flat, Gun shot.

Desert Rock V exercises for Operation Upshot-Knothole terminated with the Gun shot. Participating were 2670 troops from all Army areas and 589 troop observers. They were located in trenches 5000 yd approximately west of zero at detonation time. The extreme dust conditions prevailing in the troop material display area south of zero made entering that area unadvisable.

5.3.12 [redacted] (See Sec. 2.1.11)

(a) General Preparations. On 5 May 1953, the Director, LASL, requested permission to include the detonation of [redacted] device in the Upshot-Knothole series. The Director, Military Application, AEC, notified the Test Manager on 27 May that approval had been given by the Commission to expend the critical material. The possibility of such an additional shot being included in the Upshot-Knothole series became known to the Test Director soon after the [redacted]

[redacted]

[redacted]

The date of 1 June had been decided upon as the earliest firing date [redacted] One week was considered necessary between the Gun and [redacted] shots by the EG&G photographic and alpha groups. However, owing to the weather delays in the previous shots, EG&G was able to get ready for this shot as early as 30 May. Since 30 May was Memorial Day and also the earliest date possible and because this date would put an extra work load on the Air Operations group at Kirtland AFB, the Test Manager decided to continue with the 1 June date. Technical requirements made it preferable to detonate no earlier than $\frac{1}{2}$ hr before sunrise, but the Air Operations Officer stated this was a bad time for either visual or night targets; thus the detonation time was set as $1\frac{1}{4}$ hr prior to sunrise.

The original planning [redacted] provided for a burst height of 1050 ft over the target Area 7-3, in order to ensure good alpha data. However, because of the off-site fall-out in southern Utah and the relatively large yield of this device, the Test Director desired to use as high a burst height as possible and still assure reasonably good alpha records. After considerable discussion it was agreed to use a burst height of 1350 ft and make the target point directly above Station 3-303 (the alpha-detector station closest to target 7-3), that is, 500 ft closer to the alpha station.

The microbarographic group stated they could assure more accurate off-site blast predictions if an Mk-6 HE nonnuclear shot were made at 1350 ft at approximately the same target location at 35 min before the [redacted] shot. This request was agreed to and the Air Operations Officer arranged for a B-50 to make this drop. The target point for the Mk-6 HE was established directly over Area 7-1. It was dropped from 19,000 ft above terrain. The [redacted] was to be dropped from a B-36 from 30,000 ft MSL [redacted] On D−4 day at 0415 PDT the B-36 ran a practice mission over the test site and dropped several 500-lb inerts with spotting charges and one practice [redacted] inert. These were dropped over Area 7-1. The circular error for the practice [redacted] was 125 ft. The Air Operations Officer had previously stated no guarantee of less than 1000-ft circular error could be given for the [redacted] and the alpha group had considered this in their planning.

Weather Delay. All experimental groups were ready for the detonation on 1 June, and the Test Director's weather meeting was held at 0830 PDT on 31 May. At this meeting wind directions appeared satisfactory, but high cirrus clouds of approximately $\frac{6}{10}$ were stated to be a possibility. However, a decision was made to "execute" and look again at the situation at a 2030 PDT meeting. At the 2030 PDT weather briefing and Advisory Panel meeting the Air Weather Officer predicted suitable winds, but definite $\frac{6}{10}$ to $\frac{8}{10}$ high cirrus cover. This factor alone would not only limit bombing but would also jeopardize cloud sampling. For this reason the shot was postponed 24 hr. Since bombing planes were loaded by this time, it was decided that it would not be necessary to have the Test Director's weather meeting the following morning but that the best time to have another look at the weather would be at 1500 PDT the following day, 1 June.

Operational Delay. At the 1500 PDT weather meeting the winds aloft were forecast as follows:

Height, ft MSL	Dir°	Knots
Surface	220	20
10,000	220	20
20,000	230	40
30,000	230	50
40,000	230	40

[redacted]

The nuclear cloud in this case would very possibly pass over Salt Lake City, but because of the 1350-ft burst height the general feeling of the advisory group was that there was no cause for worry about off-site fall-out. However, the weather prediction did not eliminate the possibility of rains at Salt Lake City in the 300-mile region downstream, and this aspect of the forecast was looked upon with disfavor by everyone. The Air Weather Officer stated that the rain prediction was questionable and that a better forecast could be given later in the day. In the hope that it would be possible to get the shot off the following morning, an execute order was issued, and it was agreed to hold a 2030 weather briefing and Advisory Panel meeting.

At the 2030 meeting the winds aloft were forecast as shown below:

Height, ft MSL	Dir°	Knots
Surface	Calm	
10,000	200	18
15,000	210	25
20,000	220	30
25,000	220	30
30,000	220	40
35,000	220	50
40,000	220	40

With this wind picture the nuclear cloud would miss all population centers of any size in Nevada as well as Utah, moving west of Salt Lake City and Ogden. However, the Air Weather Officer made a definite prediction for showers in the Salt Lake City region centering around noon on 2 June. This would be about the same time or an hour later than the anticipated arrival of the nuclear cloud over that area. Because the rain-out area appeared to be definitely not over Salt Lake City, the advisory group recommended to the Test Manager that the shot be fired. The Test Manager rather reluctantly decided to continue with the test but to watch the weather forecast carefully during the remaining period.

The B-50 and B-36 bombing planes took off [redacted] as scheduled and were already well on their way to the target area when the 0130 June 2 weather data became available in the control point. This data showed that the trough which had been expected to stay west of the test area had moved to a position which centered at approximately 50 to 100 miles directly north of the proving grounds, thus causing a change of 90° in the downstream winds which would put them east of Salt Lake City instead of west. This meteorological picture did not look so favorable as the previous one.

In addition to the unfavorable weather picture at this time, two other disturbing events occurred in the control room. The first was that the radio signal being received from the high-frequency tone-release transmitter on the B-36 (for bomb release) was very unstable. This in itself was not too serious since the back up lower frequency tone signal was very stable and would have assured reliable operation of the release relay on the control panel which starts the time-signal sequence timer. The second event was that at approximately –2 hr spurious time signals of –30 min, –15 min, –5 sec, and –2½ sec originated from the control board and triggered several pieces of gear located in stations in the control point area. This incident had occurred once before at a time when the control board attendant attached an electrically operated camera for the millisecond world clock, but the difficulty could not be readily located. Both of these items added to the anxiety expressed by the Test Manager over the unfavorable weather situation, and at 0300 PDT on 2 June the Test Manager decided to cancel the mission, and the bombing planes were directed to return to their base. Because of air-operational requirements a 48-hr delay became necessary, and the next weather meeting was scheduled for 1000 PDT on 3 June.

(b) Meteorology. At 1000 PDT on 3 June an operational weather meeting was held by the Test Director. The winds aloft were forecast for shot time as follows:

SECRET – RESTRICTED DATA

Height, ft MSL	Dir°	Knots
Surface	360	03
10,000	230	10
20,000	250	30
30,000	250	50
40,000	250	60

The nuclear-cloud height was estimated to be 43,000 ft MSL. On the basis of 250° high winds and 230° 10,000 ft winds, the radiation fall-out pattern was attractive for a detonation. No precipitation within 1000 miles downstream was predicted, and this was one of the deciding factors in previous cancellations. Therefore the execute decision was made.

Table 5.12—WINDS ALOFT [redacted]

Height, ft MSL	Forecast winds for shot time*		Actual winds at 0230 PDT, D-day		Actual winds at shot time, D-day		Actual winds at 0800 PDT, D-day	
	Dir°	Knots	Dir°	Knots	Dir°	Knots	Dir°	Knots
Surface	360	05	060	03	045	03	Calm	
6,000	340	05	310	08	360	06	050	09
8,000	330	06	300	04	020	06	050	04
10,000	330	08	330	04	140	03	280	03
12,000					200	03	220	08
14,000					170	08	230	07
15,000	310	15	140	06	170	06	230	03
16,000					210	04	Calm	
18,000					270	15	Calm	
20,000	300	25	270	12	280	13	290	03
25,000	300	30	270	14	310	19	280	28
30,000	300	40	260	15	310	28	300	27
35,000	300	45	310	20	270	17	300	46
40,000	300	50	270	13	250	24	300	31
45,000	300	25	270	07	280	12		

* These data used by the Weather Officer during the 2030 PDT Advisory Panel meeting.

At the 2030 PDT weather briefing and Advisory Panel meeting the Weather Officer forecast the winds aloft for shot time on June 4 as shown in Table 5.12. The forecast gave no winds greater than 50 knots, with smaller velocities in the lower winds, and this situation was considered good from the standpoint of decay time of the fall-out from radioactive-cloud particles. Furthermore, no precipitation within 1000 miles downstream was predicted. Consideration was given to the possibility that the trough would not progress as fast as possible and that 270° winds would result. However, the estimated level of fall-out was not over 10 mr/hr, and the Test Manager's Public Relations Officer felt that inhabitants of southern Utah would not object to this low level if it occurred. It was decided to continue with the shot.

(c) Detonation. At 0200 the B-50 bomber entered the NPG area. Since the Mk-6 was nonnuclear, no IFI was necessary. The B-50 made six wind runs at 268° and dropped from 19,000 ft MSL. The Mk-6 burst at 1350 ft over target Area 7-1 at 35 min prior to the [redacted] detonation. This HE shot was for microbarographic data.

The B-36 entered the area at 0135 PDT and started its wind runs. Seven runs in all were made at 268° and a bombing altitude of 26,000 ft MSL. The B-36 dropped two 500-lb test bombs

[redacted]

over target Area 7-1 in accordance with operation plans before the final run. [redacted]

The winds at bombing altitude were 260° at 15 knots. Surface winds were calm, and the sky was clear. The nuclear cloud reached 42,500 ft MSL. Figures 5.60 and 5.61 show the detonation.

(d) Results. Project participation for the [redacted] shot was minimal. This shot was added to the program late in the operation, and no project planning had gone into a program of participation. For detailed results reference should be made to the individual project reports which are part of the Upshot-Knothole report series.

Programs 1 to 9. Programs 1 to 4 and 6 to 8 participated where previously installed equipment could be utilized or where no installation was required.

In Program 1, 24 channels of blast information were obtained. A very marked precursor shock is evident from the results. For air-blast data 15 rockets were fired successfully, and satisfactory photographic records were obtained. Additional blast data were obtained from 58 self-recording blast gages as part of Project 3.30.

Figures 5.62 and 5.63 are negative enlargements of individual frames from a shock-study film made of th[redacted] detonation. This film shows clearly the development of the precursor.

(A) This photo shows the shock wave at approximately $^{1}/_{100}$ of a second before it reaches the ground. The arrow indicates a shock wave intercepting one of the rocket trails which, due to refraction effects, is shown to be broken in the photograph.

(B) Approximately $^{1}/_{100}$ of a second later, the shock just reaches ground surface.

(C) Approximately $^{6}/_{100}$ of a second later, the shock is being regularly refracted from the ground.

(D) $^{7}/_{100}$ of a second later, development of refracted shock.

(E) $^{8}/_{100}$ of a second later, further development of refracted shock.

(F) $^{9}/_{100}$ of a second later, further development of refracted shock with possibility of first evidence of precursor development.

(G) $^{10}/_{100}$ of a second later, further development of refracted shock, with the precursor running ahead of the regular refraction.

(H) $^{11}/_{100}$ of a second later, the precursor has developed to an extent where the resolution of the photograph clearly indicates its presence.

In Project 4.5, 85 rabbits were located at distances from 10 to 42.5 miles from zero. Retina burns were observed as far as 42.5 miles.

In Project 8.10, 35 channels were operated to give successful data on basic characteristics of thermal radiation.

Programs 10 to 20. [redacted]

Programs 21 to 29. Programs 23, 24, and 29 participated in this shot. In all, 44 mice and 2 dogs were placed in one of the prototype communal shelters approximately 1300 ft from Ground Zero, and 4 dogs were placed in the entrance to this shelter. The excessive contamination prevented recovery until approximately H+10 hr, but this delay did not greatly jeopardize results.

In addition to the animal tests, pressure gages and various radiation-metering devices were placed in nearby instrument shelters and along an instrument line extending 800 to 2500 yd from Ground Zero. Successful results were reported.

[redacted]

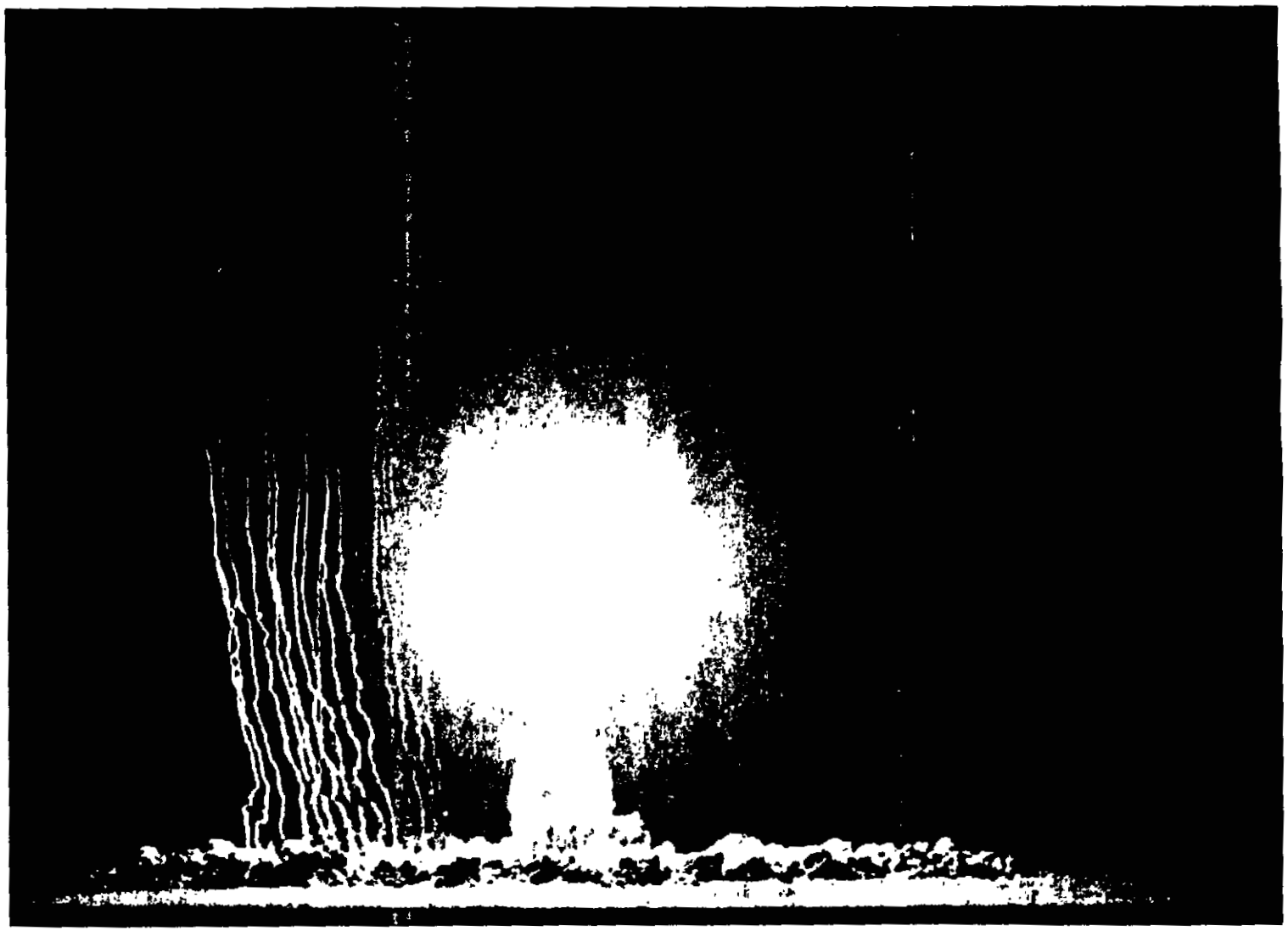


Fig. 5.60—Climax shot before dust stem reached cloud. Rocket trails for blast measurements are at left.

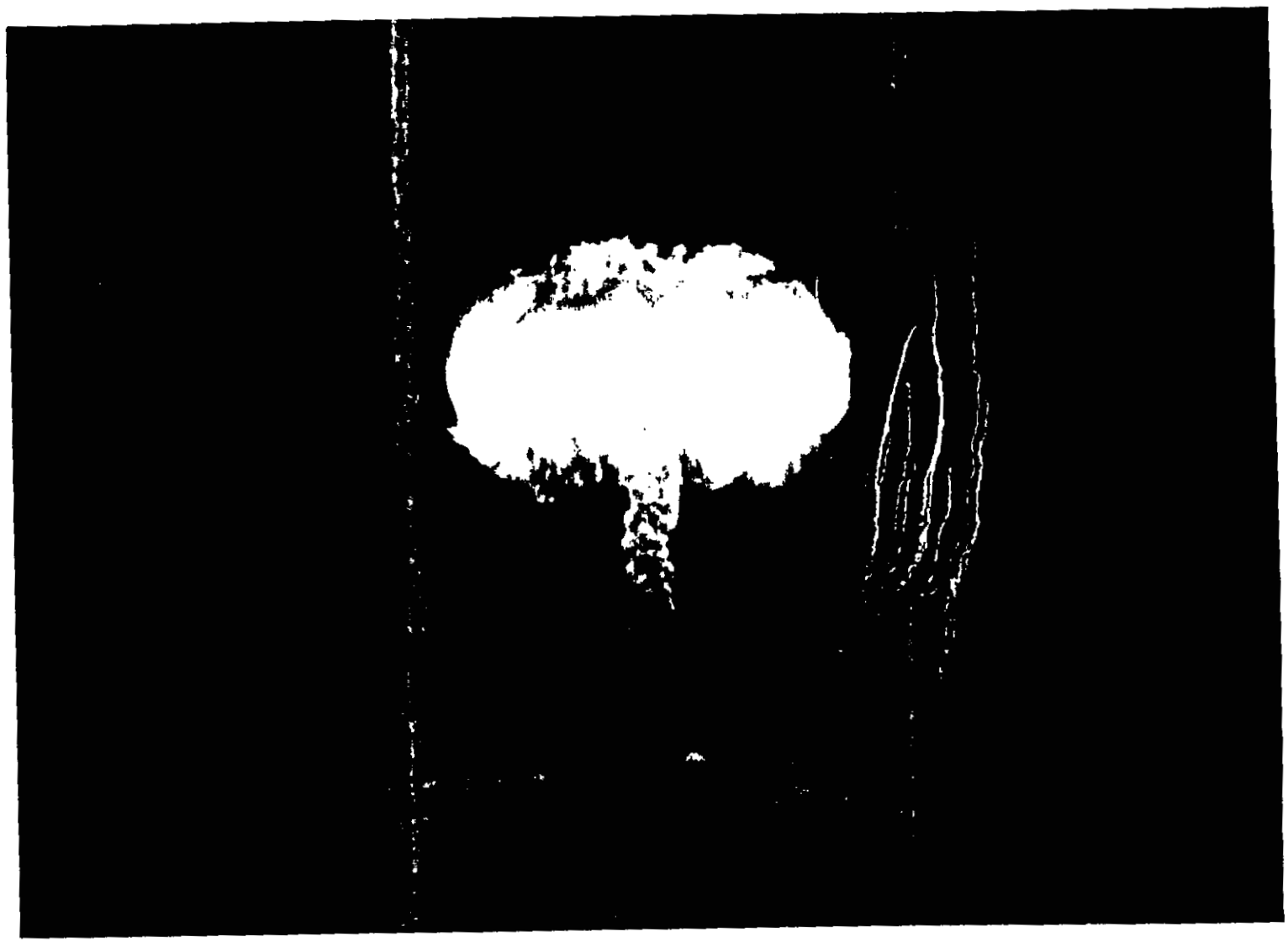


Fig. 5.81—Climax shot, dust stem mixing with cloud. The dust stem is rolling over top of the nuclear cloud. It is thought that the nuclear debris plates out on the dust particles and that these later fall out.

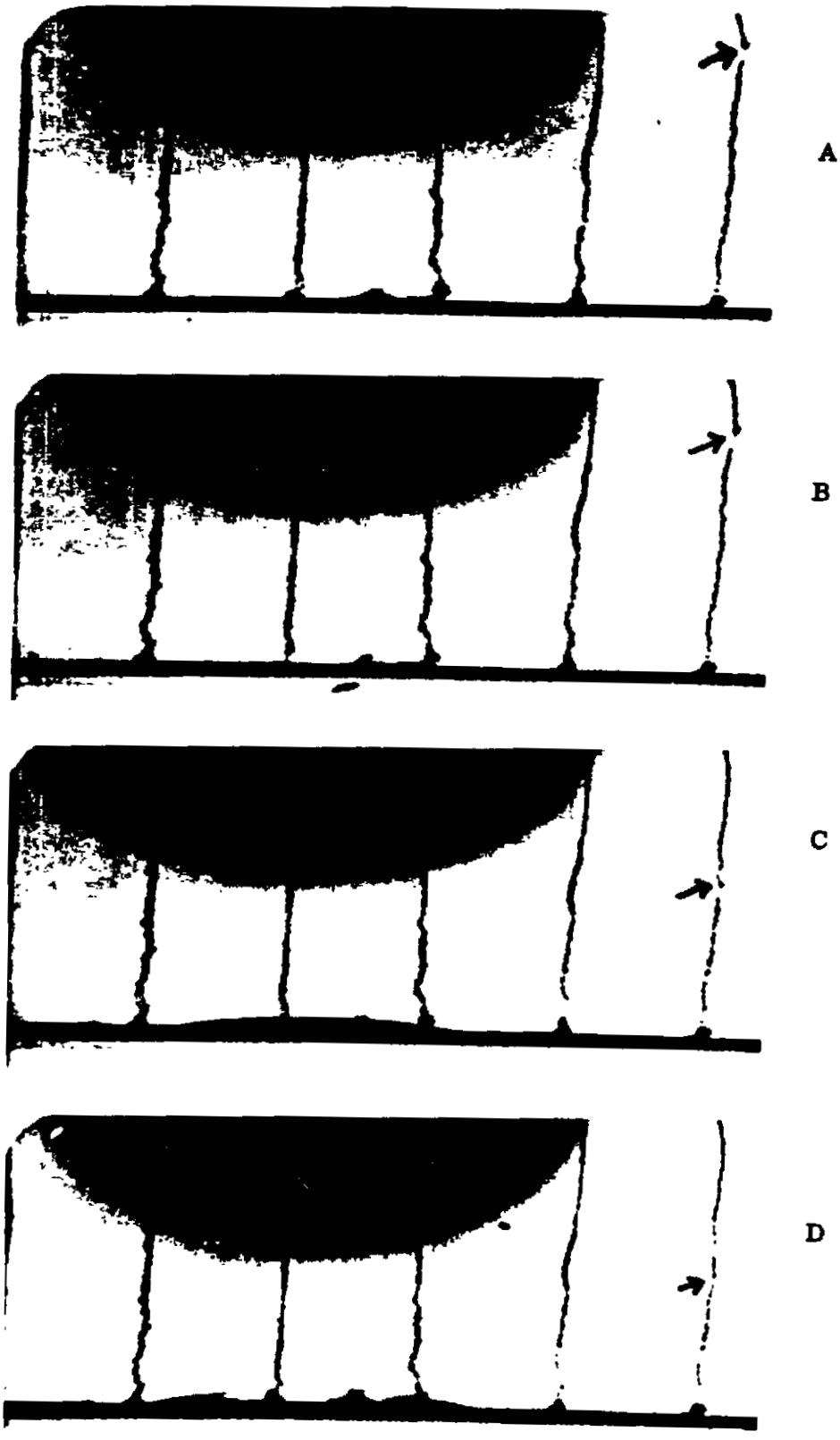


Fig. 5.62—Shock-study film [redacted] detonation.

[redacted]

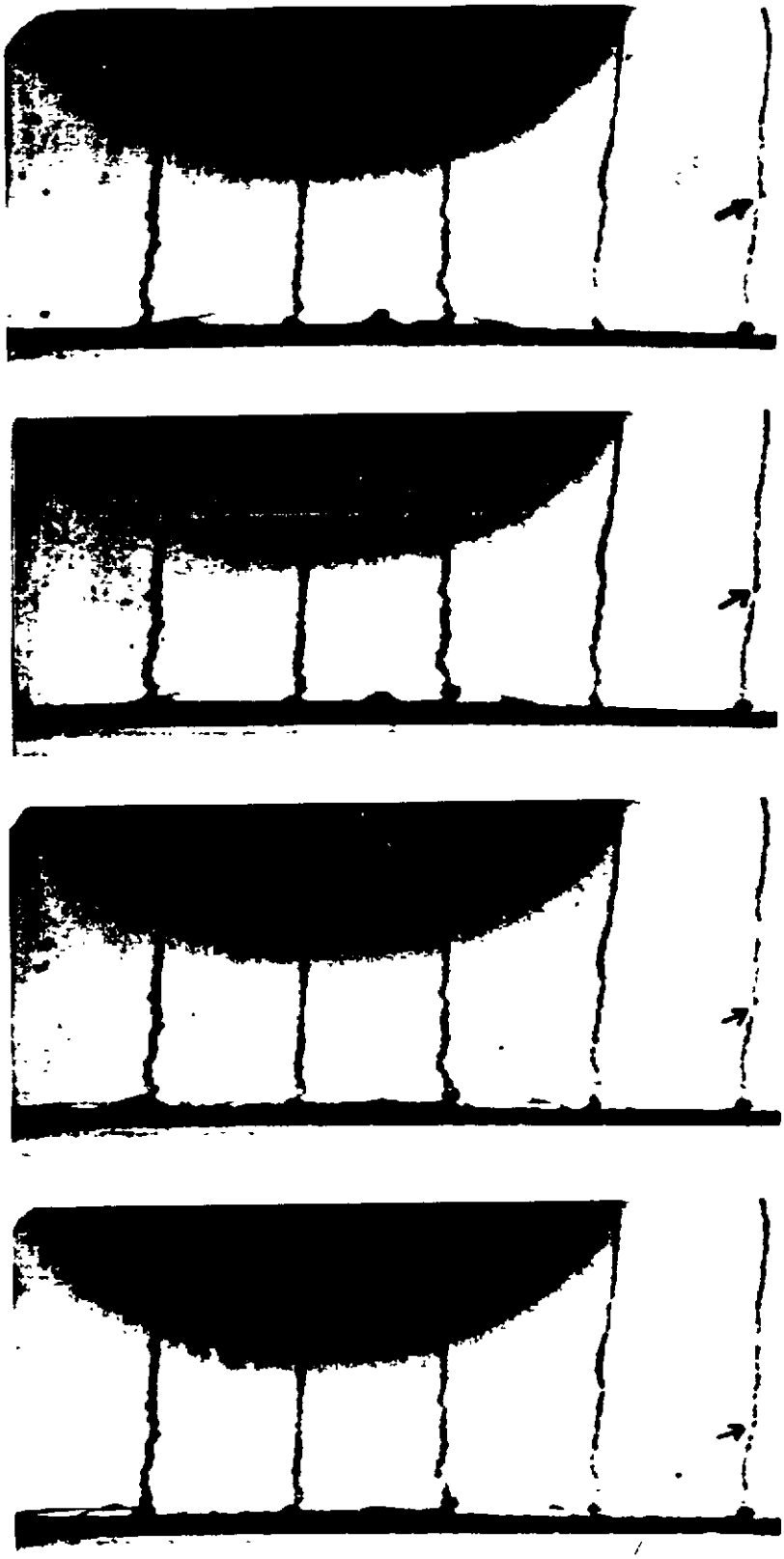
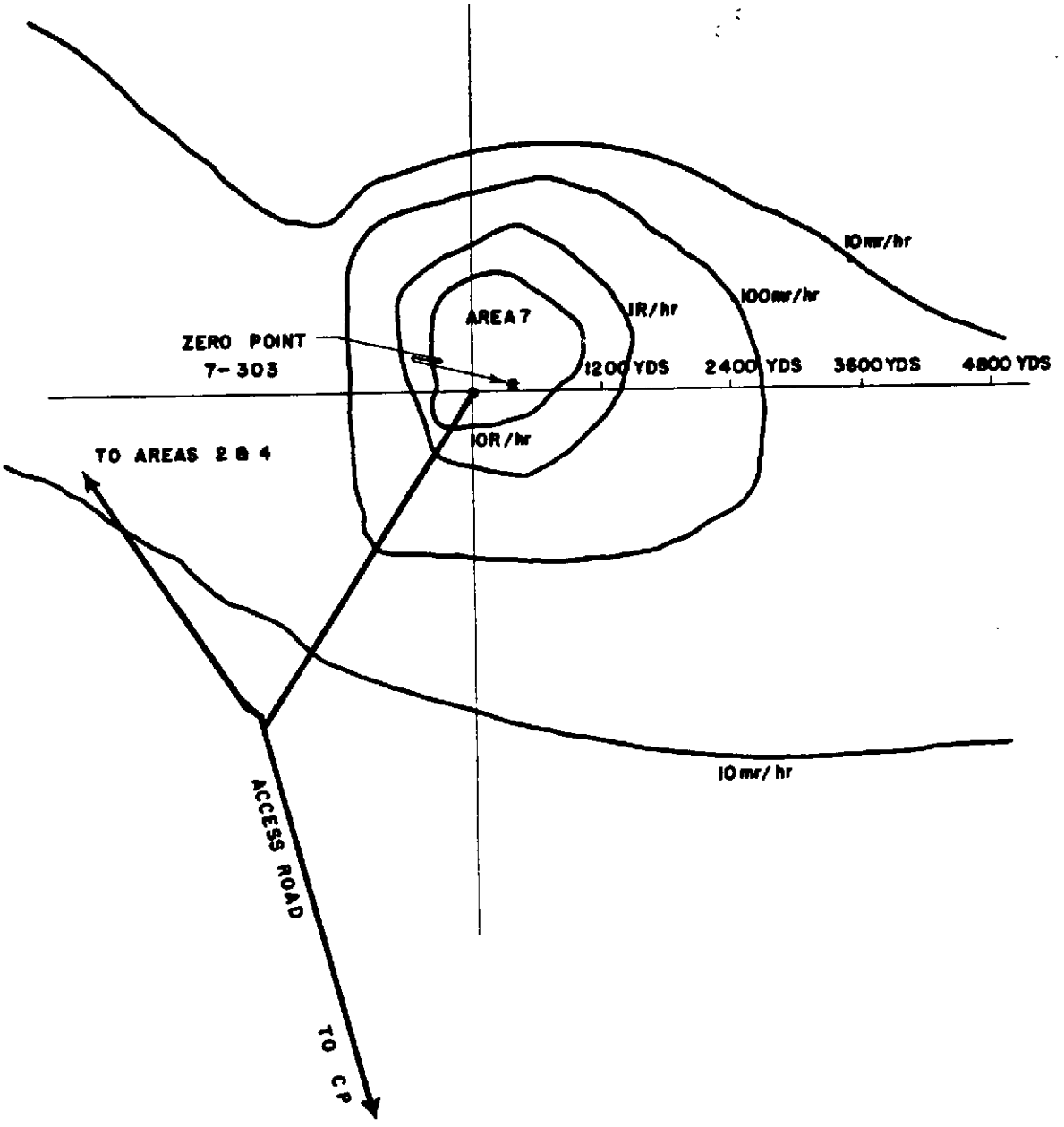


Fig. 5.63—Shock-study film of [redacted] detonation.

[redacted]



DETONATION TIME 0415 PDT, 4 JUNE 53
SURVEY TIME 0500 PDT, 4 JUNE 53

Fig. 5.64—Radiological situation, Area 7, Yucca Flat [redacted] shot.

[redacted]

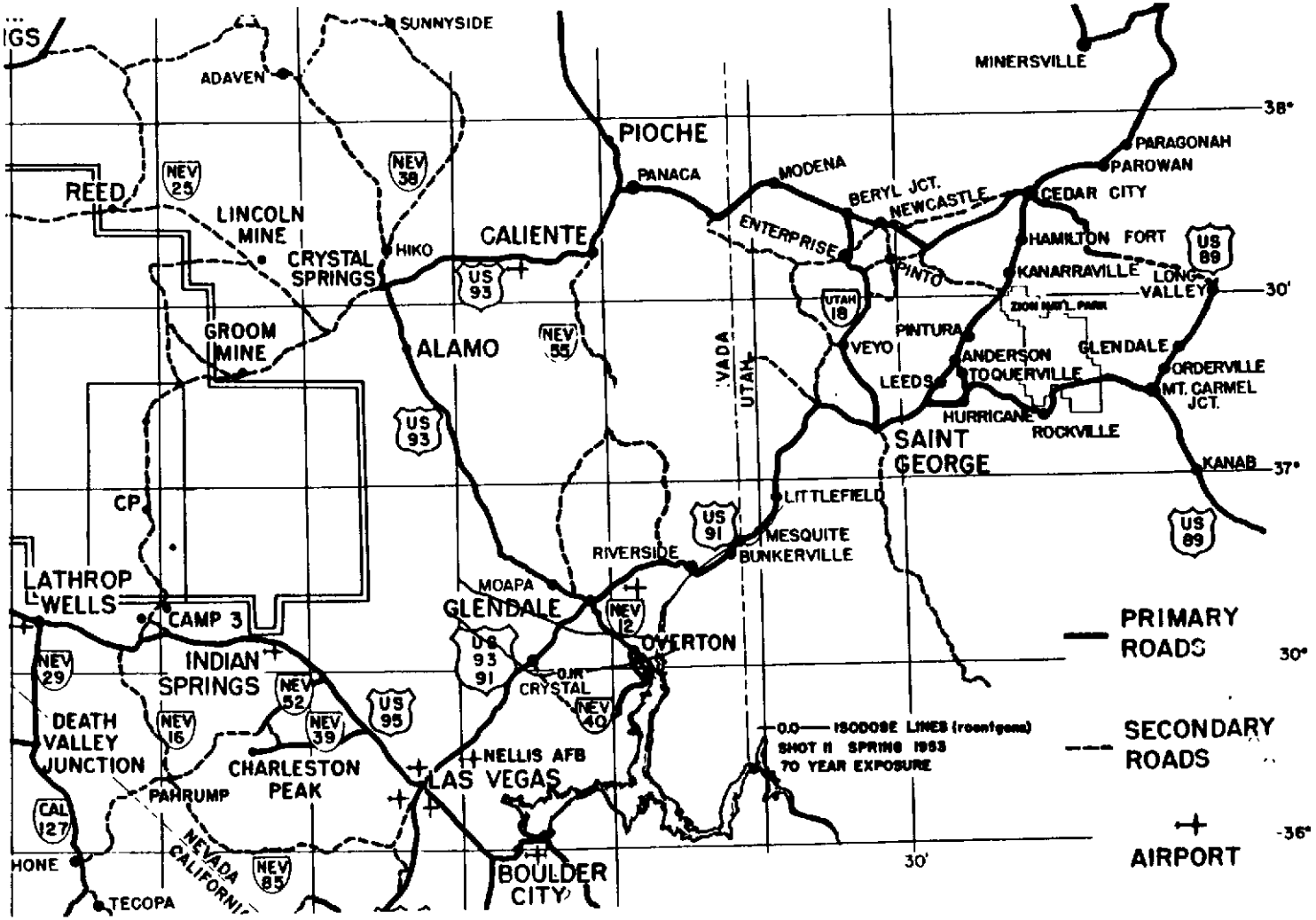


Fig. 5.65—Off-site fall-out from [redacted] detonation.

(e) On- and Off-site Fall-out. The 1350-ft air burst of this device (which gave a higher yield than any previous detonation at the continental site) did not prevent a dust stem from forming and mixing with the cloud. Although heavy ground contamination resulted, the 10-r isodose line being approximately 500 ft in radius, the off-site fall-out was very light. The upper part of the nuclear cloud passed over St. George, but no radiation levels above the existing background there were detectable.

The target-area contamination resulting from this and all previous shots in Yucca Flat is shown in Fig. 5.64. No difficulties were encountered in recovery operations, although the heavy contamination made it necessary for recovery operations to be delayed somewhat.

There were no fall-out levels higher than 12 mr/hr detected after this shot. The off-site radiation pattern is shown in Fig. 5.65. The cloud dispersed rapidly, making it difficult to track much past 100 miles from zero.

(f) Other Details of the Shot. Desert Rock V exercises were terminated with the Gun shot. They had only a few casual observers for the [redacted] detonation. There were no congressional visitors, and only a few official visitors witnessed this detonation.

Immediately following the Gun shot, the ATU kept a small group of people to make several days of test firings according to a prearranged test program with Sandia. Although these test firings in Frenchman Flat necessitated closing part of Frenchman Flat at the impact area, no great inconvenience was caused recovery personnel working in the area, and this work did not delay preparations for th[redacted]hot.

[redacted]

CHAPTER 6

OPERATIONAL AND CONSTRUCTION COSTS

6.1 GENERAL OPERATIONAL AND CONSTRUCTION COSTS

The Test Director is always concerned with the general problem of conducting an operation in such a manner that the required technical information will be acquired at a minimum cost to the Government. To date, continental nuclear tests have been of such a nature that many Government and private technical agencies have become involved. Most of the technical data required for weapon development needs are obtained by the Test Director's organization arranging for (1) a group within LASL to conduct the experiment and (2) a contract with another AEC laboratory (such as the Naval Research Laboratory or the Naval Ordnance Laboratory) or a suitable private organization (such as EG&G). Where such arrangements or contracts are made, the involved costs are known quite accurately. Likewise the major test structures which are constructed for an operation are built under contracts arranged by the Field Manager, Las Vegas Field Office (LVFO), and these costs are known. However, the Test Director has many additional requirements in connection with accomplishing an operation, such as the functions of support units. In general, these services are supplied by other Government agencies or by contracts with private organizations arranged for by the Field Manager, LVFO. The rad-chem samples are collected by an Air Force group. The weather data are supplied by the Air Weather Service of the Air Force. The Rad-Safe organization is partly military and partly civilian. For most of these services assignments of costs are much more difficult owing primarily to the fact that these operations involve personnel and equipment assigned only for the relatively short period of the operation. For instance, an estimate of the costs involved in the cloud-sampling operations for Upshot-Knothole has been made by the Special Weapons Center, Kirtland Air Force Base, and is shown in Table 6.1.

Since the establishment of NPG, a good many test structures have been constructed, and in many instances the structures have not been demolished during the tests. In general, these test structures consist of heavily reinforced concrete blockhouses necessarily located in close proximity to the zero point and built strong enough to withstand blast effects and thus protect the technical instruments and records located inside. These structures have been built according to a plan laid out for the proving grounds prior to Buster-Jangle wherein a total of at least 10 target areas can be established within the proving-grounds boundaries. In general, the initial cost of one of these blockhouses with accompanying coaxial cable and utility installations is high, ranging from $100,000 to $400,000. However, as it has turned out, these installations have been used not only for the initial test requirement but for many subsequent tests. For instance, Station 7-300, the alpha-recording station located in Area 7, was built, together with the alpha-detector stations and coax installation, at a cost of approximately $350,000. The station was built for use in Buster-Jangle, during which it was used in five detonations. Subsequently, the same installation was used for four detonations in Tumbler-Snapper and three in



Upshot-Knothole, making a total of 12 to date, and there is no reason why this same installation cannot be used for many future tests. Thus the cost of this installation per shot has been (to date) only about $29,000.

This same reasoning applies to the control building. The living facilities at the camp, the proving-grounds utility system, etc., have now been used during the 7 detonations in Buster-Jangle, the 6 in Tumbler-Snapper, and the 11 in Upshot-Knothole; making a total of 26. With the usual maintenance there is no reason why they cannot be utilized for many more operations. With the exception of living quarters in the camp, which have always been inadequate, little or no change has been made in the proving-grounds living facilities since their construction, and only a few changes or additions will be required as long as the scope of the test operations remains the same. Figures 6.1 and 6.2 are photographs of eight-man rooms at Camp Mercury.

Table 6.1—ESTIMATED SAMPLING COSTS*

Temporary duty	
Test Operations Unit 1:	
Officers (av. 48.84 at $5.00/day for 94 days)	$22,955.00
Airmen (max. 144 at $5.00/day −2 days of travel)	1,440.00
Courier flights (samples to labs):	
812 man-days at $6.00/day (av.)	4,872.00
Total temporary duty cost	$29,267.00
Aircraft operating costs	
F-84G, 631 hr at $189.57/hr†	$119,618.67
B-50, 62 hr at $344.78/hr†	21,376.36
B-25, 216 hr at $101.38/hr†	21,898.08
C-47, 565 hr at $60.91/hr†	34,414.15
Total	$197,307.26
Grand total	$226,574.26

* These costs do not include the military pay of personnel directly involved in the sampling in the amount of $167,253.36.

† Includes the following costs:

	Depot maintenance factor	Fuel cost	Lube cost	Total
F-84G	$132.01	$ 57.15	$0.41	$189.57
B-50	220.40	119.90	4.48	344.78
B-25	69.74	30.45	1.19	101.38
C-47	40.18	19.95	0.48	60.91

Table 6.2 shows the utilization of various test structures at the proving grounds. The dashes in the columns indicate the structures were not yet built.

Figure 6.3 is an aerial view of the control point area. Not shown are the VHF radio transmitter and receiving area on a hill approximately ½ mile west and 700 ft above the control point area and Building 400 (Program 18) approximately 1000 ft southwest of the control point area.

Figure 6.4 is an aerial view of Camp Mercury, NPG. The barracks, quonset huts, hutment quarters, AEC administration, recreation, and mess halls are shown in the central part of the view. At the extreme left is the military-vehicle motor pool and maintenance area, and the group of buildings in the upper part of the photograph consists of the AEC warehouses, construction contractor buildings, and the AEC motor pool and maintenance area.



Fig. 6.1—Interior of 8-man hutment, Camp Mercury, NPG.



Fig. 6.2—Interior of 8-man room, permanent barracks, Camp Mercury.

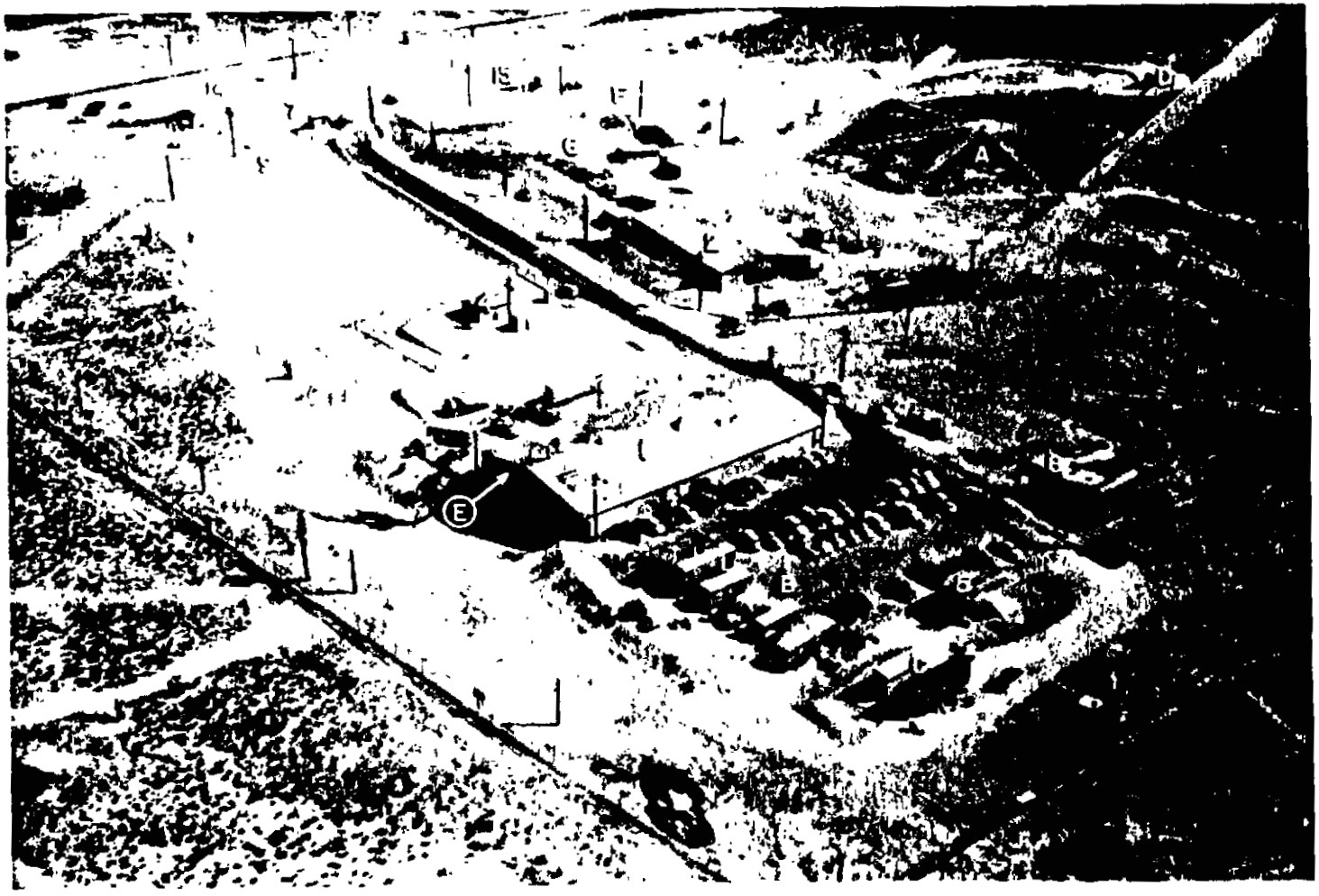


Fig. 6.3—Aerial view of control point area. (1) Control building. (2) Rad-Safe operations building. (4) Nuclear-parts storage and test building. (5) Weather-observation building. (6) Vehicle decontamination area. (7) Control point guard gate. (8) Control point water-supply reservoir and pump building. (9) Fuel storage tank for control point area. (14) Gas station. (15) Control point area electric substation. (A) Rad-Safe instrument-calibration area (see also Fig. 3.3). (B) Documentary and technical photo-processing trailers. (C) LASL Group J-13 (Project 10.4a) trailers. (D) Contaminated-waste leaching bed. (E) Control room in control point building. (F) Contaminated-equipment storage area. (G) Rad-Safe parking for contaminated vehicles. Entrance to a part of the area is through Gate 7. Units 1, 4, 5, 8, 9, B, and C being enclosed by the fence.



Fig. 6.4—Aerial view of Camp Mercury.

Table 6.2—UTILIZATION OF TEST STRUCTURES

Station	Number of times used			
	B-J	T-S	U-K	Total
1-300	-	1	1	2
2-300	-	1	1	2
3-300	-	1	2	3
4-300	-	1	2	3
7-300	5	4	3	12
F-300	-	-	2	2
3-330	-	1	2	3
4-330	-	1	1	2
2-371	-	1	0	1
1-380	-	-	1	1
4-380	-	-	1	1
1-480	-	-	1	1
4-480	-	-	1	1
CP-400	-	8	11	19
2-1000	-	1	1	2
7-1000	-	4	3	7
F-200 series	-	1	2	3
7-200 series	-	3	5	8
1-235	-	1	1	2
2-235	-	1	1	2
3-235	-	1	4	5
4-235	-	1	1	2

6.2 ACCOUNTING SYSTEM FOR PROJECTS

In an effort to allocate the operational and construction costs involved in a continental test directly to the project conducting an experiment, the Test Director in conjunction with SFOO established a detailed cost-accounting system during Operation Buster-Jangle. The system was improved during Tumbler-Snapper and was further improved during Upshot-Knothole. In this system the cost-accounting number assigned to each project is the project number (see participation chart, Appendix A). Items which are common to a program and common to all projects in the program are assigned a cost-accounting number made up of the program number plus ".99," i.e., items common to projects in Program 7 are charged to 7.99.

The accounting numbers for general items of cost are shown in Table 6.3.

With this accounting system all job requests initiated by any project within the Test Director's organization were processed by the Test Director's Engineering and Construction section and from them were passed on to the Field Manager, who, in turn, accomplished the work by means of the various construction and operational contractors.

Tables 6.4, 6.5, and 6.6 are included not so much to account for funds spent by the various projects but to illustrate the manner in which test project and operational costs are kept. Table 6.4 shows costs incurred by Programs 10 to 20, along with costs which are common to all the test programs and which are necessary for the operation. One sees, for instance, that the Upshot-Knothole microbarographic group costs totalled $87,429.00. The microbarographic group from Sandia procured newly developed gages and other instruments for this operation, and these costs are included. On the other hand, the AEC costs for the Weather Unit amounted to only $25,036.00, this being mostly temporary duty for military personnel. The outlying weather sta-

(Text continues on page 130.)

APPENDIX C

OPERATION UPSHOT-KNOTHOLE REPORT SERIES

Project No.	Title	Agency	WT No.*
	GENERAL		
	Deputy Test Director's Report	LASL	816
	Handbook of Diagnostic Experiments	LASL	707
	Staff Reports	LASL	822
	Radiological Safety	AFSWP	817
	Weapon Assembly	Sandia	704
	Nuclear Core Design and Handling	UCRL-Livermore	701
	Timing and Firing	EG&G	806
	Air Weather Service Participation	SWC	703
	Activities of Special Weather Advisory Service	LASL	705
	Aircraft Participation	SWC	
	Microbarographic Studies	Sandia	800
	Activities of the Artillery Test Unit	Fort Sill	709
	Full Scale Test of the Atomic Shell. Phase III: Shell Effects and Performance	AFSWP	783
	Preliminary [redacted] Interpretations	UCRL-Livermore	815
	Summary Report for Programs 1 to 9	AFSWP	782
	MILITARY EFFECTS		
	Program 1 Blast and Shock Measurements		
1.1a, 1.2	Air Blast Measurements	NOL	710
1.1a-1	Evaluation of Wiancko and Vibration Gauges and Development of New Circuitry for Atomic Blast Measurements	NOL	784
1.1a-2	The Development of Mechanical Pressure-Time and Peak Pressure Recorders for Atomic Blast Measurements	NOL	785
1.1b	Air Pressure and Ground Shock Measurements	SRI	711
1.1c-1	Air Shock Pressure Time Vs Distance for a Tower Shot	Sandia	712
1.1c-2	Air Shock Pressures as Affected by Hills and Dales	Sandia	713
1.1d	Dynamic Pressure Vs Time and Supporting Air Blast Measurements	Sandia	714
1.3	Free-air Atomic Blast Pressure Measurements	AFCRC	715

*Reports not yet received at LASL have not been assigned WT numbers.

[redacted]

Project No.	Title	Agency	WT No.
1.4	Vertical Earth Stress and Earth Stress and Strain Systems	Sandia	716
1.5	Test Procedures and Instrumentation for Projects 1.1c, 1.1d, 1.4a, 1.4b	Sandia	787
	Program 2 Nuclear Measurements and Effects		
2.1	Radioactive Particle Studies Inside an Aircraft	ACC	717
2.2a	Gamma Radiation Spectrum of Residual Contamination	SCEL	718
2.2b	Residual Gamma Depth Dose Measurements in Unit-density Material	NMRI	719
2.3	Neutron Flux Measurements	NRL	720
	Program 3 Structures, Material, and Equipment		
3.1	Air Force Structure Program	WADC	721
3.1a	Shock Diffraction Study in the Vicinity of a Structure		786
3.3	Tests on the Loading of Horizontal Cylindrical Shapes	WADC	722
3.4	Tests on the Loading of Truss Systems Common to Open Frame Structures	WADC	723
3.5	Tests on the Response of Wall and Roof Panels and the Transmission of Load to Supporting Structure	WADC	724
3.6	Tests on the Loading and Response of Railroad Equipment	Transportation Corps, WADC	725
3.7	Air Blast Effects on Entrances and Air Intakes of Underground Installations	OCE	726
3.8	Air Blast Effects on Underground Structures	OCE	727
3.9	Field Fortifications	ERDL	728
3.11-3.16	Navy Structures	BuDocks	729
3.18	Minefield Clearance	ERDL	730
3.19	Blast Damage to Coniferous Tree Stands by Atomic Explosions	Dept. Agr.	731
3.20	The Blast and Thermal Effects of an Atomic Bomb on Typical Tactical Communication Systems	SCEL	732
3.21	Statistical Estimation of Damage to Ordnance Equipment Exposed to Nuclear Blasts	BRL	733
3.22	Effects on Engineer Bridging Equipment	ERDL	734
3.24	Effects of an Air Burst Atomic Explosion on Landing Vehicles, Tracked (LVT'S)	NRDL	735
3.26, 1, 2, 3	Air Force Structures Program	AMC-OCE	736
3.27	Effects of Atomic Explosions on Field Medical Installations Equipment	Med Fld Ser Sch	737
3.28.1	Structures Instrumentation	BRL	738
3.28.2	Pressure Measurements for Various Projects of Program Three	NOL	739
3.28.3	Pressure Measurements on Structures	SRI	740
3.29	Blast Effects of Atomic Weapons Upon Curtain Walls and Partitions of Masonry and Other Materials	FCDA	741
3.30	Air Blast Gage Studies	BRL	742
	Program 4 Biomedical Effects		
4.1	The Radiation Hazards to Personnel within an Atomic Cloud	AFCRC	743
4.2	Direct Air Blast Exposure Effects on Animals	NMRI	744
4.5	Flash Blindness	SchAvMed (RAFB)	745
4.7	Beta-Gamma Ratio in the Postshot Contaminated Area	Surg Gen	746
4.8	The Biological Effectiveness of Neutron Radiation from the Nuclear Artillery Shell in Free Air and in Foxholes	NRDL	747

Project No.	Title	Agency	WT No.
	Program 5 Aircraft Structures Test		
5.1	Atomic Weapon Effects on AD Type Aircraft in Flight	BuAer	748
5.2	Atomic Weapon Effects on B-50 Type Aircraft in Flight	WADC	749
5.3	Blast Effects on B-36 Type Aircraft in Flight	WADC	750
	Program 6 Tests of Service Equipment and Operations		
6.2	IBDA Phenomena and Techniques	WADC	751
6.3	Interim IBDA Capabilities of Strategic Air Command	SAC	752
6.4	Evaluation of Chemical Dosimeters	ACC	753
6.7	Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations	SCEL-ESL	754
6.8	Evaluation of Military Radiac Equipment	SCEL-BS	755
6.8a	Initial Gamma Exposure Vs Distance	SCEL	756
6.9	Evaluation of Naval Airborne Radiac Equipment	BuAer	757
6.10	Evaulation of Rapid Aerial Radiological Survey Techniques	SCEL	758
6.11	Indoctrination of Tactical Air Command Air Crews in the Delivery and Effects of Atomic Weapons	TAC	759
6.12	Determination of Height of Burst and Ground Zero	AFF, ESL	760
6.13	Effectiveness of Fast Scan Radar for Fireball Studies and Weapons Tracking	NEL	761
	Program 7 Long-range Detection		
7.1	Electromagnetic Effects of Nuclear Explosions	AFOAT-1	762
7.3	Detection of Airborne Low Frequency Sound from the Nuclear Explosions	AFOAT-1	763
7.4	Seismic Measurements	AFOAT-1	764
7.5	Calibration Analysis of Close-in A-Bomb Debris	AFOAT-1	765
	Program 8 Thermal Measurements and Effects		
8.1a	Effects of Thermal and Blast Forces from Nuclear Detonations on Basic Aircraft Structures and Components	WADC	766
8.1b	Additional Data on the Vulnerability of Parked Aircraft to Atomic Bombs	WADC	809
8.2	Measurement of Thermal Radiation with a Vacuum Microphone	AFCRC	767
8.4-1	Protection Afforded by Operational Smoke Screens Against Thermal Radiation	ACC	768
8.4-2	Evaluation of a Thermal Absorbing Carbon Smoke Screen	ACC	769
8.5	Thermal Radiation Protection Afforded Test Animals by Fabric Assemblies	QtrmR&DL	770
8.6	Performance Characteristics of Clothing Materials Exposed to Thermal Radiation	QtrmR&DL	771
8.9	Effects of Thermal Radiation on Materials	NMRL	772
8.10	Physical Characteristics of Thermal Radiation from an Atomic Bomb Detonation	NRDL	773
8.11a	Incendiary Effects on Building and Interior Kindling Fuels	Forestry Service	774
8.11b	Ignition and Persistent Fires Resulting from Atomic Explosions Exterior Kindling Fuels	Forestry Service	775
8.12a	Sound Velocities Near the Ground in the Vicinity of an Atomic Explosion	NEL	776

[redacted] DATA

Project No.	Title	Agency	WT No.
8.12b	Supplementary Pressure Measurements	David Taylor Mod. Bas.	777
8.13	Study of Fire-retarding Paint	ERDC	778
	Program 9 Technical Photography		
9.1	Technical Photography Final Report	AFSWP	779
9.6	Production Stabilization	Waterways Experimental Station	780
9.7	Experimental Soil Stabilization	Waterways Experimental Station	781
	Program 10 Gamma-ray Measurements		
10.1, 10.2a	Alpha and Transit-time Measurements on [redacted]ests	UCRL-Livermore	708
10.1	Alpha and Transit-time Measurements	EG&G	807
10.2b	Remote Transit-time Measurements	Sandia	
10.3	Total Gamma Vs Distance with Film Badges	LASL	
10.4	A Measurement of Teller Alpha	LASL	706
10.4	Investigation of an Alpha Telemetering System	LASL	799
	Program 11 [redacted]nvestigations		
	[redacted] Investigations	LASL	
	Program 12 Technical Photography		
12.1	Technical Photography	EG&G	
12.1	Bhangmeter Mod II	EG&G	788
12.2	High-speed Photography	LASL	
	Program 13 Radiochemistry		
13.1	Radiochemical Studies	LASL	
13.2	Radiochemical Measurements by UCRL for Upshot	UCRL-Livermore	
	Program 14 [redacted] Measurements		
14	[redacted]	LASL	818
	Program 15 Electromagnetic Investigations		
15.2	Measurements of Electric Transients in the Earth	Sandia	813
15.3	A Survey of Electromagnetic Effects Observed during Upshot	UCRL-Livermore	797
15.4	Investigation of Early Electromagnetic Signals	LASL	791
	Program 17 Neutron Measurements		
17.1	Integral Neutron Measurements (Threshold Detectors)	LASL	
17.2	Neutron Spectrum Measurements (Nuclear Emulsion Plates)	LASL	
17.3	Tenex	LASL	
17.4	Neutron Energy Distribution on [redacted]	UCRL-Livermore	804

[redacted]

Project No.	Title	Agency	WT No.
	Program 18 Thermal Radiation		
18.1, 2, 6	Thermal Radiation Measurements: Part I—Total Thermal Radiation and Air Attenuation; Part II—Power as a Function of Time (Photocells); Part III—Surface Brightness Investigations (Bowens & Slits)	NRL	
18.3	A Preliminary Survey of High Dispersion Spectrograms Obtained at Upshot-Knothole	NRL	
18.4	Light Absorption Characteristics of Region Surrounding Fireball	NRL	
18.5	Doppler Shift Investigations of Case Motion	NRL	
	CIVIL EFFECTS STUDIES		
	Program 21 Civil Defense Effects		
21.1	Effects of an Atomic Explosion on Underground and Basement Types of Home Shelters	AEC-FCDA	801
21.2	Effects of An Atomic Explosion on Two Typical Two-story-and-basement Wood-frame Houses	FCDA	792
21.3	Air-zero Locators	FCDA	
	Program 22 FDCA Radef and Radiation Effects		
22.1	Evaluation of Training Program for Radiological Defense Personnel	FCDA	808
22.2	Various Aspects of Nuclear Radiation Measurements for Civil Defense Radiological Defense Purposes	FCDA	805
22.3	Radiological Hazards in Civil Defense	FCDA	
22.4	Exposure of Drugs to Nuclear Explosions	FDA	810
	Program 23 Biomedical Experiments		
23.1	Biological Effectiveness of Ionizing Radiation within Shelter	NRDL	793
23.2	Bacteriological Studies on Animals Exposed to Neutron Radiation	NRDL	794
23.3	Long-Term Studies on Dogs Exposed to Primarily Neutron Irradiation in Shelters	NRDL	
23.4–23.14, 23.16	Genetic Effects of Fast Neutrons from Nuclear Radiations	AEC	820
23.15	Effects of Overpressures in Group Shelters on Animals and Dummies	Lovelace Clinic	798
23.17	Neutron Flux Measurements in AEC Communal Shelters and Lead Hemispheres	NRDL	795
	Program 24 AEC Shelter Structures		
24.1	Evaluation of Communal Shelters	AEC	
24.2	Physical Measurements of Gamma and Neutron Radiation in Shelter and Instrumentation Evaluation	AEC	789
24.3	AEC Shelter Instrumentation	Vitro	790

Project No.	Title	Agency	WT No.
	Program 26 Civilian Vehicle Tests		
26.1, 26.2	Physical, Mechanical, and Irradiation Evaluation of Civilian Vehicles Exposed to Atomic Attack	AEC-FCDA	
	Program 27 Fall-out Studies in Near Areas		
27.1	Distribution and Characteristics of Fall-out at Distances Greater Than Ten Miles From Ground Zero, March and April 1953	UCLA-AEP	811
27.2	Environmental and Biological Fate of Fall-out From Nuclear Detonations in Areas Adjacent to the Nevada Proving Grounds	UCLA-AEP	812
	Program 28 Radiation Telemetering System		
28.1	Test of a Radiation Telemetering System	AEC	796
	Program 29 Dosimetry and Radiation Measurements		
29.1	Comparison and Evaluation of Dosimetry Methods Applicable to Gamma Radiation	UCLA	802
29.2	Fast Neutrons Effects on Semi-conductors	UCLA	803
29.3	Evaluation of Dosimetry for Civil Effects Programs	AEC	
29.4	Effective Energy of Residual Gamma Radiation	U. Rochester	814

Table 6.3—CHART OF SPECIAL TEST ACCOUNTS, GENERAL ITEMS OF COST

Agency	Cost code
Test Director's office and Task Units' operations:	
Rad-Safe	31.1
Weather Unit	31.2
Documentary photography	31.3
Assembly	31.4
Aircraft Participation Unit	31.5
Microbarographic studies	31.6
Firing Party	31.7
Test Director's office and staff	31.99
Operations and items common to DOD Programs 1 to 9:	
Area stabilization	32.1
Timing and firing	32.2
Test power facilities	32.3
Roads	32.4
Photography support	32.5
Support and material furnished DOD organizations	32.6
Personnel and equipment assistance	32.7
Communications other than project	32.8
Gas and oil furnished DOD organizations	32.9
Receiving and shipping DOD equipment and material	32.10
Camp construction and rehabilitation	32.11
Rehabilitation of test structures and equipment	32.12
Cabling and trenching	32.13
Instrumentation and camera shelters	32.14
All other support	32.15
Common to Programs 10 to 20*	33.99
Common to FCDA projects and Programs 21 to 29*	34.99
Common to AEC biomedical projects and Programs 21 to 29*	35.99
Test Manager's office and staff	36.99

*These accounts were charged with costs that could not be identified with specific projects and programs but could be associated with a specific group of programs.

Table 6.4—CONSOLIDATED AEC TEST COST REPORT, UPSHOT-KNOTHOLE*
(Cumulative, as of June 30, 1953)

Program and project	Agency	Scientific operations	Logistical operations	Expendable construction	Total
Program 1:					
Project 1.99†	Common to Program 1	$ 10,634			$ 10,634
	Total	$ 10,634			$ 10,634
Program 10:					
Project 10.1	EG&G, LASL J-13	$ 696,138	$ 52,293	$ 798,229	$ 1,546,660
Project 10.2	EG&G, SC, LASL J-13, LASL W-5	$ 200,871	6,271		207,142
Project 10.3‡	LASL J-13		5,618		5,618
Project 10.4	LASL J-13	94,161	12,753	7,320	114,234
Project 10.99	Common to Program 10		45,697	1,506	47,203
	Total	$ 991,170	$ 122,632	$ 807,055	$ 1,920,857

[redacted]

Table 6.4 — (Continued)

Program and project	Agency	Scientific operations	Logistical operations	Expendable construction	Total
Program 11:					
Project 11.99	LASL J-16	$ 157,565	$ 17,878	$ 582,663	$ 758,106
	Total	$ 157,565	$ 17,878	$ 582,663	$ 758,106
Program 12:					
Project 12.1	EG&G	$ 209,137	$ 23,247	$ 28,836	$ 261,220
Project 12.2	LASL J-15	86,167	16,368	86,743	189,278
Project 12.3	UCRL		3,281	4,211	7,492
Project 12.99	Common to Program 12		12,556	163,413	175,969
	Total	$ 295,304	$ 55,452	$ 283,203	$ 633,959
Program 13:					
Project 13.1	LASL J-11	$ 314,463	$ 34		$ 314,497
Project 13.2	UCRL		1,096		1,096
Project 13.99	Common to Program 13		2,654		2,654
	Total	$ 314,463	$ 3,784		$ 318,247
Program 14:					
Project 14.99‡	LASL W-5		$ 17,130	$ 8,254	$ 25,384
	Total		$ 17,130	$ 8,254	$ 25,384
Program 15:					
Project 15.2	SC	$ 527,957	$ 4,455	$ 7,403	$ 539,815
Project 15.3	UCRL		1,853	3,379	5,232
Project 15.4	LASL J-13	8,116	5,572	14,895	28,583
Project 15.99	Common to Program 15		1,774		1,774
	Total	$ 536,073	$ 13,654	$ 25,677	$ 575,404
Program 16:					
Project 16.99	Common to Program 16	$ 96,084	$ 9		$ 96,093
	Total	$ 96,084	$ 9		$ 96,093
Program 17:					
Project 17.1	LASL J-12	$ 31,576	$ 6,434	$ 6,436	$ 44,446
Project 17.2	LASL J-12	32,436	7,694	5,190	45,320
Project 17.3	LASL J-12	32,071			32,071
Project 17.4	UCRL		2,253	312	2,565
Project 17.5	UCRL		1,024		1,024
Project 17.99	Common to Program 17	20,161	9,606	848	30,615
	Total	$ 116,244	$ 27,011	$ 12,786	$ 156,041
Program 18:					
Project 18.1	NRL	$ 21,712	$ 142	$ 1,008	$ 22,862
Project 18.2	NRL	55,832			55,832
Project 18.3	NRL	12,407			12,407
Project 18.4	NRL	6,204	20,260	70,631	97,095
Project 18.5	NRL		31		31
Project 18.6	NRL	38,772			38,772
Project 18.99	Common to Program 18	12,905	31,724	39,464	84,093
	Total	$ 147,832	$ 52,157	$ 111,103	$ 311,092

[redacted]

Table 6.4 — (Continued)

Program and project	Agency	Scientific operations	Logistical operations	Expendable construction	Total
Program 20:					
Project 20.99	EG&G	$ 245,648	$ 39,486	$ 76,264	$ 361,398
	Total	$ 245,648	$ 39,486	$ 76,264	$ 361,398
Program 31:					
Project 31.1	Rad-Safe		$ 75,571		$ 75,571
Project 31.2	Weather Unit		17,082	$ 7,954	25,036
Project 31.3	Documentary photography		5,893	310	6,203
Project 31.4	Assembly	$ 203,593	88		203,681
Project 31.5	Air Participation Unit		32,595	324	32,919
Project 31.6	Microbarographic study	61,510	20,253	5,666	87,429
Project 31.99	Test director's office and staff		52,547	554	53,101
	Total	$ 265,103	$ 204,029	$ 14,808	$ 483,940
Program 33:					
Project 33.99	Common to Programs 10 to 20	$ 316,535	$3,204,945§	$1,452,257	$ 4,973,737
	Total	$ 316,535	$3,204,945	$1,452,257	$ 4,973,737
Program 36:					
Project 36.99	Test Manager's office and staff		$ 24,186		$ 24,186
	Total		$ 24,186		$ 24,186
Total Upshot-Knothole costs		$3,492,655¶	$3,782,353	$3,374,070	$10,649,078

* Only costs incurred by Santa Fe Operations are included in this report, and the UCRL projects reflect only support costs incurred by the SFOO contractor.

† Entire cost reflected in this project represents DOD nonreimbursable work by Sandia.

‡ No costs reported by scientific contractor. Review has been requested of cost allocations for these projects which presumably have been completed.

§ This includes the following costs: support to scientific contractors, $338,321; Las Vegas Field Office expenses, $590,565; cost of operation and maintenance of NPG, $2,276,059; all of which total $3,204,945. In previous reports the Las Vegas expenditures were included in the totals for field office and operation and maintenance of NPG. The figure for NPG maintenance here also includes an estimate of $75,000 to complete the job.

¶ Includes estimate of $104,750 to complete job.

Table 6.5—COST AND FUND REPORT, REIMBURSABLE WORK, DOD, UPSHOT-KNOTHOLE
(Cumulative as of June 30, 1954)

Program and project	Operations	Construction	Total
Program 1:			
Project 1.1	$ 29,816	$ 80,008	$ 109,824
Project 1.2	368	795	1,163
Project 1.3	2,258	486	2,744
Project 1.4	3,152	1,706	4,858
Project 1.99	47,409*		47,409
Total	$ 83,003	$ 82,995	$ 165,998
Program 2:			
Project 2.3	$ 432		$ 432
Project 2.99	104		104
Total	$ 536		$ 536
Program 3:			
Project 3.1	$ 182	$ 105,434	$ 105,616
Project 3.3	108	38,137	38,245
Project 3.4	438	201,172	201,610
Project 3.5	3,870	134,602	138,472
Project 3.6	2,487	15,635	18,122
Project 3.7	1,331	74,039	75,370
Project 3.8	2,207	63,049	65,256
Project 3.11	917	53,819	54,736
Project 3.12	337	33,091	33,428
Project 3.13	2,883	101,613	104,496
Project 3.14	45	82,807	82,852
Project 3.15	709	27,510	28,219
Project 3.16	3,986	42,245	46,231
Project 3.19	1,032	50,077	51,109
Project 3.20	303		303
Project 3.21	931		931
Project 3.22	619		619
Project 3.24	2,042		2,042
Project 3.26	1,245	33,597	34,842
Project 3.27	2,774		2,774
Project 3.28	6,623	171,559	178,182
Project 3.29		36,149	36,149
Project 3.99	9,411		9,411
Total	$ 44,480	$1,264,535	$1,309,015
Program 4:			
Project 4.1	$ 6,160		$ 6,160
Project 4.2	2,770	13,462	16,232
Project 4.99	251		251
Total	$ 9,181	$ 13,462	$ 22,643
Program 5:			
Project 5.1	$ 1,168		$ 1,168
Project 5.99	287		287
Total	$ 1,455		$ 1,455
Program 6:			
Project 6.2	$ 4,540	$ 5,323	$ 9,863
Project 6.7	188		188



Table 6.5 (Continued)

Program and project	Operations	Construction	Total
Project 6.8	413		413
Project 6.99	474		474
Total	$ 5,615	$ 5,323	10,938
Program 7:			
Project 7.1	$ 281		$ 281
Project 7.99	46		46
Total	$ 327		$ 327
Program 8:			
Project 8.1	$ 2,688	$ 57,830	$ 60,518
Project 8.2	1,127		1,127
Project 8.4	6,470	13,506	19,976
Project 8.5	541	32	573
Project 8.6	442	33	475
Project 8.9	324	233	557
Project 8.10	2,405	9,665	12,070
Project 8.11	3,083	1,562	4,645
Project 8.12	3,631	13,019	16,660
Project 8.99	6,887	159	7,046
Total	$ 27,598	$ 96,039	$ 123,637
Program 9:			
Project 9.1	$ 2,061	$ 1,462	$ 3,523
Project 9.6	1,663	8,382	10,045
Project 9.7	1,246		1,246
Project 9.99	1,152		1,152
Total	$ 6,122	$ 9,844	$ 15,966
Program 12:			
Project 12.9	$186,052†		$ 186,052
Total	$186,052		$ 186,052
Program 32:			
Project 32.1	$ 23,244	$ 287,154	$ 310,398
Project 32.2	33,800	100,941	134,741
Project 32.3	5,838	145,221	151,059
Project 32.4	5,828	41	5,869
Project 32.6	14,145		14,145
Project 32.7	37,527		37,527
Project 32.8	11,461		11,461
Project 32.9	48,938		48,938
Project 32.10	36,453		36,453
Project 32.11	15,314	17,379	32,693
Project 32.12	3,794	7,214	11,008
Project 32.13	9,966	44,135	54,101
Project 32.14	11,247	122,238	133,485
Project 32.15	42,134	13,588	55,722
Total	$299,689	$ 737,911	$1,037,600
Grand total	$664,058	$2,210,109	$2,874,167

* Includes $42,225 pertaining to Projects 1.1 and 1.4 reported and transferred by Sandia as Project 1.99.

† Includes year to date adjustment of EG&G costs in the amount of $30,674.

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Table 6.6—COST AND FUND REPORT, CIVIL EFFECTS PROGRAMS AND PROJECTS, UPSHOT-KNOTHOLE
(Cumulative as of June 30, 1953)

Program and project	Agency		Operations	Construction	Total
Program 21:					
Project 21.1	AEC-DBM		$ 107	$ 14,409	$ 14,516
Project 21.2	FCDA		3,323	33,079	36,402
Project 21.3	FCDA		891		891
Project 21.99	Common to Program 21		1,018		1,018
		Total	$ 5,339	$ 47,488	$ 52,827
Program 22:					
Project 22.4	FCDA-FDA		$ 138		$ 138
Project 22.99	Common to Program 22		267		267
		Total	$ 405		$ 405
Program 23:					
Project 23.1	AEC (NMRI-NRDL)		$ 11,065	$ 9,242	$ 20,307
Project 23.3	AEC (NMRI-NRDL)		125		125
Project 23.4	AEC-A		2,255		2,255
Project 23.10	AEC-ORNL		439		439
Project 23.15	AEC-IS		8,958	7,182	16,140
Project 23.17	AEC (NMRI-NRDL)		148		148
Project 23.99	Common to Program 23		7,484	24,007	31,491
		Total	$ 30,474	$ 40,431	$ 70,905
Program 24:					
Project 24.1	AEC-DBM		$ 5,510	$ 20,881	$ 26,391
Project 24.2	AEC-DBM		3,204		3,204
Project 24.3	AEC-VITRO		39,397	144,795	184,192
Project 24.99	Common to Program 24		4,521	83,020	87,541
		Total	$ 52,632	$248,696	$301,328
Program 26:					
Project 26.1	AEC		$ 951		$ 951
Project 26.2	FCDA		342		342
		Total	$ 1,293		$ 1.293
Program 27:					
Project 27.2	AEC (UCLA,AEP)		$ 275		$ 275
Project 27.99	Common to Program 27		10,900	$ 1,209	12,109
		Total	$ 11,175	$ 1,209	$ 12,384
Program 28:					
Project 28.1	AEC-DBM		$ 737		$ 737
		Total	$ 737		$ 737
Program 29:					
Project 29.1	AEC-UCLA		$ 780		$ 780
Project 29.2	AEC-UCLA		207		207
Project 29.3	AEC-DBM		268		268
Project 29.4	AEC-R		66		66
		Total	$ 1,321		$ 1,321



CHAPTER 7

CONCLUSIONS

7.1 OPERATIONAL DETAILS

The operational details for Operation Upshot-Knothole are enumerated in the preceding sections of this report. Upshot-Knothole differed somewhat from previous continental tests in several respects, namely:

1. Practically all the facilities at the proving grounds which are required for carrying on a series of tests were completely available before the start of the operation. In previous test series construction of many of the required facilities was not complete, and improvisations were often necessary.

2. The operational and many of the test personnel were familiar with continental test procedures, having been associated with previous tests conducted both at Nevada and Eniwetok.

3. Upshot-Knothole was held approximately one year after Tumbler-Snapper. Operation Ranger was a "quickie" type of test with little planning time, followed in six months by Buster-Jangle, which in turn was followed in six months by Tumbler-Snapper. Six months is a very minimum period of time for the comprehensive and economic planning involved in operations of this kind. Although the Eniwetok test, Ivy, was conducted between Tumbler-Snapper and Upshot-Knothole, nevertheless the longer period between these two continental tests provided more time to plan Upshot-Knothole carefully and likewise more time for the Field Manager, LVFO, to carry out the construction contract negotiations which resulted in less expensive construction costs.

4. Upshot-Knothole consisted of 11 nuclear detonations, compared with 5 for Ranger, 7 for Buster-Jangle, and 8 for Tumbler-Snapper. In addition, there were considerably more "fringe" operations, such as the FCDA open shot with news media, television, and invited observers; the Gun shot added rather late in the planning stages; and the [redacted]hot added in the latter part of the actual operation.

5. The Rad-Safe organization differed slightly from that utilized in previous tests in that U. S. Public Health Service personnel performed a major part of the off-site duties.

Operationally Upshot-Knothole was considerably smoother from the Test Director's standpoint than any previous continental test series. There were no major handicaps; the weather for the first seven shots caused no delays. Camp Mercury living, although considerably overcrowded, was better than had previously been experienced. There were no major transportation problems. Power and telephone communications functioned very well. Administrative relations within all factions of the test organization were exceptionally good. Difficulties were experienced with off-site radio communications, and there were some unfortunate off-site radiation fall-out occurrences, primarily in southern Utah. The off-site radio problem is one that is not easily solved. Improvements have been made during each of the continental tests, but

[redacted]

more are required, and solutions are being sought. The off-site fall-out has been thoroughly investigated since the conclusion of the tests, and considerable thought is being given to further minimizing bomb-debris fall-out in future tests without limiting the yield of the devices tested to lower than those of Upshot-Knothole. Methods of improving the weather forecasting are under consideration and will be incorporated in future tests.

The personnel directly associated with the Test Director's organization, as well as the military and civilian AEC and contractor personnel associated with the Field Manager's support units, seemed to cooperate more closely with one another during this operation than for any previous continental test series. In any event, from the Test Director's standpoint the administrative problems associated with the operation were minimal; yet the over-all operation was more involved than any previous continental series. The Test Manager's organization for Upshot-Knothole was built around that of the Test Director's in such a way as to furnish the Test Director with every assistance necessary to accomplish the tests, and the organization certainly functioned in this manner.

7.2 TECHNICAL DETAILS

Technical investigations during Upshot-Knothole covered a wider range of subjects with more agencies participating than for any previous test series. The technical results obtained from all the projects doing experiments are contained in individual program and project reports forming a part of the Upshot-Knothole report series. There are, however, general remarks which can be made which summarize the technical requirements and accomplishments.

During the planning phases of the technical aspects of the operation, all requests for tests submitted by the Military Effects, Weapons Development, and Civil Effects Test Groups were included in the test schedule. The Military Effects Test Group proposals were all of the conventional type of test which could be incorporated in the program with no question, except tests involving drone plane operations. Drones had not previously been involved in NPG operations, and their operation was considered to be somewhat hazardous not only to personnel in the test area but also to personnel in areas outside the proving ground. Decision for inclusion of these drone tests was left up to the Test Manager, and, after a suitable operations plan which minimized the operational hazards was worked out, the drones were allowed. There were no difficulties encountered, and some very valuable data were obtained on the subject of radiation hazards associated with flight through an atomic cloud.

The Effects and Gun shots likewise provided a great mass of data for the groups concerned with effects from atomic detonations. Many of these data were of a confirming nature. The Gun shot was of primary interest to the ground forces of the DOD in the nature of proof testing the Gun device, and it is felt that all the desired information was obtained on this subject. The Civil Effects Test Group, incorporated into the test organization for the first time during Upshot-Knothole, carried out a program of effects tests, some of which were a continuation of previous test series. Every effort was made to fulfill as many of the FCDA requests as feasible. The decision to have an open shot (the request for which originated with FDCA) was made by the AEC.

The Livermore group of UCRL sponsored two of the weapon development detonations. Cooperation between this group and the test organization was very satisfactory, and it is believed that all the technical information desired from these tests was obtained. In addition, the UCRL group obtained indoctrination in test procedures which will prove of value to them in future operations.

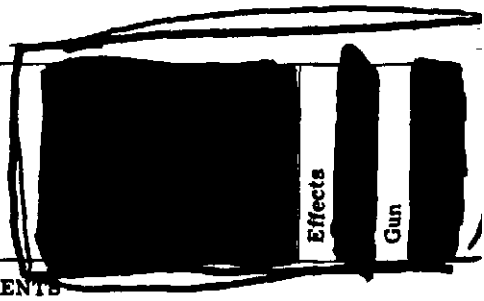
Table 7.1 summarizes, in a general way, the major technical accomplishments of Upshot-Knothole from the standpoint of weapon development. Not included are the usual weapon development experiments to determine yield, alpha, transit time, gamma, neutron and thermal radiation, and technical photography since these experiments have been done as a part of nuclear tests since their inception.

In Table 7.1 the major technical accomplishments resulting from Upshot-Knothole are tabulated in nine categories. A brief summary discussion of each follows:

Pages 133 - 136 are deleted.

APPENDIX A

SCHEDULE OF PROJECT PARTICIPATION



	Project	Agency												
	PROGRAM 1 BLAST MEASUREMENTS													
1.1a	Basic air-blast measurements	NOL									x	x	x	
1.1b	Basic air-blast measurements	ONR-SRI			x	x					x		x	x
1.1c	Basic air-blast measurements	Sandia	x						x					
1.1d	Basic air-blast supplementary measurements	Sandia									x		x	
1.2	Air-blast measurements	NOL	x			x					x		x	x
1.3	Free-air-blast pressure measurements	AFCRC				x					x			
1.4a	Earth measurements	Sandia	x								x		x	
1.4b	Earth measurements	Sandia									x		x	
	PROGRAM 2 NUCLEAR MEASUREMENTS AND EFFECTS													
2.1	Studies of airborne particulate material	ACC				x					x			
2.2a	Measurement of gamma-radiation fission products	SCEL		x	x	x		x	x		x	x	x	x
2.2b	Residual gamma depth-dose measurements in unit density material	NMRI						x	x		x		x	
2.3	Neutron flux and spectrum vs range	NRL									x	x	x	
	PROGRAM 3 STRUCTURES, MATERIAL, AND EQUIPMENT													
3.1	Tests on loading of building and equipment shapes	AMC									x		x	
3.3	Tests on horizontal cylindrical shapes	AMC									x		x	
3.4	Tests of truss systems common to open frame structures	AMC									x		x	
3.5	Tests of wall and roof panels	AMC									x			
3.6	Tests of railroad equipment	USA Trans. Corps-AMC											x	

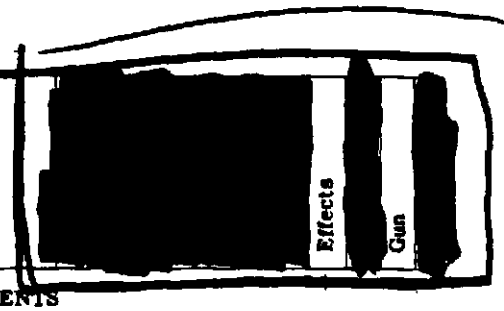
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	Project	Agency										Effects		Gun	
3.7	Effectiveness of blast baffles at shelter entrances; air intake and/or outlets	OCE										x		x	
3.8	Effects of air blast on buried structures	OCE										x		x	
3.9	Design and location of field fortifications	ERDC										x		x	
3.11	Protective measures for existing constructional light-steel-frame structures	BuYds Docks										x			
3.12	Protective measures for existing construction; external protective measures	BuYds Docks										x			
3.13	Precast gable shelters; model of blast-resistant panel	BuYds Docks										x		x	
3.14	Precast warehouse	BuYds Docks										x		x	
3.15	Armco steel magazine	BuYds Docks										x		x	
3.16	Tests of glazing and window construction	BuYds Docks										x		x	
3.18	Minefield clearance	ERDC												x	
3.19	Effects of atomic explosion on trees in forest stand	Forest Service										x		x	
3.20	Vulnerability of typical tactical communications systems to atomic attack	SCEL										x		x	
3.21	Statistical determination of damage criteria for critical items of military equipment and supplies	BRL										x		x	
3.22	Effects on engineer bridging equipment	ERDL										x		x	
3.24	Effects of air-burst atomic explosion on LVT's	NRDL										x		x	
3.26.1	Tests on the effects on POL installations—drum and tank storage	AMC										x		x	
3.26.2	Effects on POL installations—systems and hazards from spillage	QMC										x		x	
3.26.3	Effects on POL installations—bulk storage	USMC										x		x	
3.27	Effects of atomic weapons on field medical installations	US Med. Fld. Ser. Schl.										x			
3.28.1	Structures instrumentation	BRL										x		x	
3.28.2	Structures instrumentation	NOL										x		x	
3.28.3	Structures instrumentation	SRI										x		x	
3.29	Tests of 4 FCDA curtain-wall and partition structures	FCDA										x			
3.30	Field test of self-recording gages	BRL									x	x	x	x	x
	PROGRAM 4 BIOMEDICAL EFFECTS														
4.1	Evaluation of hazard of flying through atomic cloud	AFCRC						x				x			
4.2	Air-blast injuries	NMRI										x	x	x	

	Project	Agency											
4.5	Flash blindness	USAF Schl. Avia. Med.	x	x				x	x		x	x	
4.7	Measurement of beta hazard in bomb-contaminated areas	USA Off. Sur. Gen.		x						x	x	x	x
4.8	Biological effects of neutrons	NRDL										x	
	PROGRAM 5 AIRCRAFT STRUCTURES TEST												
5.1	Naval aircraft structures	NAMC	x	x					x	x			
5.2	Blast, thermal, and gust effects on aircraft in flight	WADC				x				x			
5.3	Blast, thermal, and gust effects on B-36 aircraft in flight	WADC								x			
	PROGRAM 6 TESTS OF SERVICE EQUIPMENT AND OPERATIONS												
6.2	Test of radar techniques for accomplishing IBDA	WADC	x	x	x	x	x	x	x	x	x	x	x
6.3	Field test of IBDA	SAC	x	x		x		x	x	x	x	x	x
6.4	Evaluation of chemical dosimeter	Chem. Corps CRL							x	x			
6.7	Electromagnetic radiation over the radio spectrum	SCEL	x	x	x	x	x	x	x	x		x	x
6.8	Evaluation of radiac instrumentation, equipment, and operational techniques	SCEL, BuShips	x	x	x	x	x	x	x	x	x	x	
6.9	Evaluation of airborne radiac equipment	BuAer	x	x	x			x	x				
6.10	Rapid aerial radiological survey	SCEL	x	x	x			x	x	x	x	x	
6.11	Operational training of TAC crews	TAC				x				x			
6.12	Determination of height of burst and Ground Zero	AFF, ESL	x	x	x	x	x	x	x	x	x	x	x
6.13	Effectiveness of fast-scan radar	NEL							x	x	x	x	
	PROGRAM 7 LONG-RANGE DETECTION												
7.1	Electromagnetic effects from nuclear explosions	AFOAT-1	x	x	x	x	x	x	x	x	x	x	x
7.2	Detection of fireball light at distance	AFOAT-1	x	x	x	x	x	x	x	x	x	x	x
7.3	Detection of airborne low-frequency sound from atomic explosion	AFOAT-1	x	x	x	x	x	x	x	x	x	x	x
7.4	Seismic measurements	AFOAT-1	x	x	x	x	x	x	x	x	x	x	x
7.5	Calibration analysis of bomb debris	AFOAT-1	x	x	x	x	x	x	x	x	x	x	x
	PROGRAM 8 THERMAL MEASUREMENTS AND EFFECTS												
8.1	Aircraft-structures tests	WADC	x		x		x	x	x	x	x	x	
8.2	Measurement of thermal radiation by means of radiation-pressure phenomena	AFCRC	x	x	x	x	x	x	x	x	x	x	
8.4	Attenuation of thermal radiation by white scattering smoke; effects of black absorbing smoke on thermal radiation and blast	ACC								x		x	

	Project	Agency	[redacted]							Effects		Gun	
8.5	Degree and extent of burns under service uniforms	QMC-RDL		x						x		x	
8.6	Thermal effects on clothing, materials, panel tests	QMC-RDL								x		x	
8.9	Effects of thermal radiation on materials	NML								x		x	x
8.10	Measurement of basic characteristics of thermal radiation	NRDL			x	x				x		x	x
8.11a	Initiation and resistance of primary fires	Forest Products Lab.								x		x	
8.11b	Initiation and persistence of primary fires	Forest Service				x				x		x	
8.12a	Measurement of velocity of sound	NEL							x	x		x	
8.12b	Precursor-shock study	David Taylor Mod. Bas.								x		x	
8.13	Study of fire-retardant paint	ERDC								x			
	PROGRAM 9 TECHNICAL PHOTOGRAPHY												
9.1	Technical photography	EG&G	x	x	x	x	x	x	x	x	x	x	x
9.6	Stabilization (production)	DWET								x		x	
9.7	Stabilization (experimental)	US Corps Engineers								x		x	
	PROGRAM 10 GAMMA-RAY MEASUREMENTS												
10.1	Alpha	EG&G, LASL(J-13)	x	x	x		x	x	x	x	x	x	x
10.2a	Transit time, tower shots	EG&G, LASL(J-13)	x	x	x		x	x	x		x		
10.2b	Remote transit time	Sandia		x	x	x				x			x
10.2c	XR transit time	LASL(W-5)	x								x		
10.3	Total gamma dose	LASL(H-6)					x	x				x	x
10.4	New techniques	LASL(J-13)			x	x		x	x	x	x	x	x
	PROGRAM 11 [redacted] NVESTIGATIONS												
		LASL(J-16)		x					x				
	PROGRAM 12 TECHNICAL PHOTOGRAPHY												
12.1a	Burst position	EG&G				x				x		x	x
12.1b	Ball-of-fire photography	EG&G	x	x	x	x	x	x	x	x	x	x	x
12.1c	Cloud phenomena	EG&G	x	x	x	x	x	x	x	x	x	x	x
12.1d	Illumination vs time	EG&G	x	x	x	x	x	x	x	x	x	x	x
12.1e	Early fireball growth	EG&G	x	x	x	x	x	x	x	x	x	x	x
12.1f	Bhangmeters	EG&G	x	x	x	x	x	x	x	x	x	x	x
12.1h	Monochromatic photography	EG&G	x	x	x	x	x	x	x	x	x	x	
12.2a	Hot-spot experiments	LASL(J-15)							x				
12.2b	Case-motion photography	LASL(J-15)		x					x				
12.2c	Framing cameras	LASL(J-15)	x	x	x				x		x		
12.2d	Radiative growth	LASL(J-15)	x		x								
12.3	UCRL photography	UCRL-Livermore					x				x		
	PROGRAM 13 RADIOCHEMISTRY												
13.1	LASL rad-chem	LASL(J-11)	x	x	x	x	x	x	x	x	x	x	x
13.2	UCRL rad-chem	UCRL-Livermore			x		x						

[redacted]



Project	Agency											
PROGRAM 14 [redacted] MEASUREMENTS												
	LASL(W-5)	x								x		
PROGRAM 15 ELECTROMAGNETIC INVESTIGATIONS												
15.2 Transient studies	Sandia		x							x		
15.3 Electromagnetic pickup	UCRL-Livermore	x	x							x		x
15.4 Early electromagnetic signals	LASL(J-13)	x	x	x	x	x	x	x	x	x	x	x
PROGRAM 17 NEUTRON MEASUREMENTS												
17.1 Integral neutrons (TD's)	LASL(J-12)	x	x				x	x			x	
17.2 Neutron spectrum (Phonex)	LASL(J-12)						x	x				
17.3 Tenex	LASL(J-12)			x				x				
17.4 Neutron spectrum (Phonex)	UCRL-Livermore			x		x						
17.5 Integral neutrons	UCRL-Livermore			x		x						
PROGRAM 18 THERMAL RADIATION												
18.1 Total thermal and air attenuation	NRL	x	x	x	x	x	x	x	x	x	x	x
18.2 Power vs time	NRL	x	x	x	x	x	x	x	x	x	x	
18.3 Spectrum	NRL	x	x	x	x	x	x	x	x	x	x	
18.4 Light absorption	NRL	x								x		
18.5 Case-surface brightness	NRL							x				
18.6 Surface-brightness investigation	NRL	x	x	x	x	x	x	x	x	x	x	
PROGRAM 21 CIVIL DEFENSE EFFECTS STUDIES												
21.1 Home shelters	FCDA	x										
21.2 Typical residences	FCDA	x										
21.3 Air-zero locators	FCDA	x							x			
PROGRAM 22 FCDA RADEF AND RADIATION EFFECTS												
22.1 Evaluation of Radef survey methods	FCDA							x				
22.2 Evaluation of DC Radef instruments	FCDA						x	x	x			
22.3 Evaluation of radiological hazards in CD	FCDA							x				
22.4 Drug irradiation studies	FCDA-FDA							x		x		
PROGRAM 23 BIOMEDICAL EXPERIMENTS												
23.1 Determination of biological effectiveness of ionizing radiation within shelter	NMRI, NRDL	x		x	x				x	x		x
23.2 Bacteriological studies on dogs exposed to primarily neutron irradiation	NMRI, NRDL	x		x	x				x	x		
23.3 Long-term studies on animals exposed primarily to neutron irradiation	NMRI, NRDL	x		x	x				x	x		

[redacted]

	Project	Agency	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Effects	Gun	[redacted]
23.4	Effects of neutron irradiation on longevity and production of sex-linked and autosomal lethal mutations in Drosophilidae	AEC-Amherst	x								x	
23.5	Effects of neutrons on spores of smuts and rusts	AEC-U. of Minn.	x								x	
23.6	Somatic mutations in Drosophila	ORNL	x								x	
23.7	Drosophila chromosome breaks	AEC-Cal. Tech.	x								x	
23.8	Drosophila LD and first-generation lethals	AEC-Iowa State	x							x	x	
23.9	Dosage/mutation curve and color mutations in wasp Mormoniella males	AEC-U. of Pa.	x								x	
23.10	Effects of neutron on chromosome breaks in Tradescantia	ORNL	x									
23.11	Chromosome breaks and mutations in Datura	AEC-Smith	x									
23.12	Reverse mutations in Neurospora	ORNL	x							x	x	
23.13	Dominant lethals and sterility in mice	ORNL	x									
23.14	LD and first-generation lethals on mice of two stocks exposed to same dose	AEC-Iowa State	x							x		
23.15	Effects of overpressures, displacement, and missiles on animals	AEC-Lovelace	x							x		x
23.16	Chromosome breaks in maize seed	ORNL	x								x	
23.17	Dosimetry for biological experiments to be conducted in conjunction with AEC shelter testing	NRDL, NMRI	x		x	x				x	x	x
	PROGRAM 24 AEC SHELTER STRUCTURES											
24.1	AEC shelter evaluation	AEC-BM	x							x		x
24.2	Physical measurements of gamma and neutron radiation in shelters, including instrumentation evaluation	AEC-BM	x					x		x	x	x
24.3	Physical measurements of static and dynamic overpressures and thermal radiation in shelters	Vitro	x							x		
	PROGRAM 26 CIVILIAN VEHICLE TESTS											
26.1	Biomedical evaluation of vehicles as shelters	FCDA	x		x	x				x		x
26.2	Physical and mechanical evaluation of vehicles exposed to atomic attack	FCDA	x		x	x				x		
	PROGRAM 27 FALL-OUT STUDIES IN NEAR AREAS											
27.1	Physical evaluation of fall-out materials	UCLA, AEP		x	x	x		x	x			

[redacted]

	Project	Agency	Effects	Gun										
27.2	Biological effects on native animals of inhalation and ingestion of fall-out material and evaluation of soil contamination	UCLA, AEP			x	x			x	x				
	PROGRAM 28 RADIATION TELEMETERING SYSTEM													
28.1	Radiation monitoring system using a radio telemetering link for transmission of data	AEC-BM			x	x	x	x		x	x			
	PROGRAM 29 DOSIMETRY AND RADIATION MEASUREMENTS													
29.1	Compilation and evaluation of dosimetry methods applicable to gamma radiation	UCLA					x	x	x	x	x	x	x	x
29.2	Study and measure fast neutrons in field test by means of permanent electrical-resistance changes produced by them in semiconductors	UCLA			x							x		x
29.3	Coordination and evaluation of dosimetry within civil effects programs	AEC-BM			x	x	x	x	x		x			
29.4	Measurement of effective energy and spectral distribution of residual radiation	AEC-Rochester			x	x					x			

Pages 144-154 are deleted

APPENDIX C

OPERATION UPSHOT-KNOTHOLE REPORT SERIES

Project No.	Title	Agency	WT No.*
	GENERAL		
	Deputy Test Director's Report	LASL	816
	Handbook of Diagnostic Experiments	LASL	707
	Staff Reports	LASL	822
	Radiological Safety	AFSWP	817
	Weapon Assembly	Sandia	704
	Nuclear Core Design and Handling	UCRL-Livermore	701
	Timing and Firing	EG&G	806
	Air Weather Service Participation	SWC	703
	Activities of Special Weather Advisory Service	LASL	705
	Aircraft Participation	SWC	
	Microbarographic Studies	Sandia	800
	Activities of the Artillery Test Unit	Fort Sill	709
	Full Scale Test of the Atomic Shell. Phase III: Shell Effects and Performance	AFSWP	783
	Preliminary [redacted] Interpretations	UCRL-Livermore	815
	Summary Report for Programs 1 to 9	AFSWP	782
	MILITARY EFFECTS		
	Program 1 Blast and Shock Measurements		
1.1a, 1.2	Air Blast Measurements	NOL	710
1.1a-1	Evaluation of Wiancko and Vibration Gauges and Development of New Circuitry for Atomic Blast Measurements	NOL	784
1.1a-2	The Development of Mechanical Pressure-Time and Peak Pressure Recorders for Atomic Blast Measurements	NOL	785
1.1b	Air Pressure and Ground Shock Measurements	SRI	711
1.1c-1	Air Shock Pressure Time Vs Distance for a Tower Shot	Sandia	712
1.1c-2	Air Shock Pressures as Affected by Hills and Dales	Sandia	713
1.1d	Dynamic Pressure Vs Time and Supporting Air Blast Measurements	Sandia	714
1.3	Free-air Atomic Blast Pressure Measurements	AFCRC	715

*Reports not yet received at LASL have not been assigned WT numbers.

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Project No.	Title	Agency	WT No.
1.4	Vertical Earth Stress and Earth Stress and Strain Systems	Sandia	716
1.5	Test Procedures and Instrumentation for Projects 1.1c, 1.1d, 1.4a, 1.4b	Sandia	787
	Program 2 Nuclear Measurements and Effects		
2.1	Radioactive Particle Studies Inside an Aircraft	ACC	717
2.2a	Gamma Radiation Spectrum of Residual Contamination	SCEL	718
2.2b	Residual Gamma Depth Dose Measurements in Unit-density Material	NMRI	719
2.3	Neutron Flux Measurements	NRL	720
	Program 3 Structures, Material, and Equipment		
3.1	Air Force Structure Program	WADC	721
3.1a	Shock Diffraction Study in the Vicinity of a Structure		786
3.3	Tests on the Loading of Horizontal Cylindrical Shapes	WADC	722
3.4	Tests on the Loading of Truss Systems Common to Open Frame Structures	WADC	723
3.5	Tests on the Response of Wall and Roof Panels and the Transmission of Load to Supporting Structure	WADC	724
3.6	Tests on the Loading and Response of Railroad Equipment	Transportation Corps, WADC	725
3.7	Air Blast Effects on Entrances and Air Intakes of Underground Installations	OCE	726
3.8	Air Blast Effects on Underground Structures	OCE	727
3.9	Field Fortifications	ERDL	728
3.11-3.16	Navy Structures	BuDocks	729
3.18	Minefield Clearance	ERDL	730
3.19	Blast Damage to Coniferous Tree Stands by Atomic Explosions	Dept. Agr.	731
3.20	The Blast and Thermal Effects of an Atomic Bomb on Typical Tactical Communication Systems	SCEL	732
3.21	Statistical Estimation of Damage to Ordnance Equipment Exposed to Nuclear Blasts	BRL	733
3.22	Effects on Engineer Bridging Equipment	ERDL	734
3.24	Effects of an Air Burst Atomic Explosion on Landing Vehicles, Tracked (LVT'S)	NRDL	735
3.26, 1, 2, 3	Air Force Structures Program	AMC-OCE	736
3.27	Effects of Atomic Explosions on Field Medical Installations Equipment	Med Fld Ser Sch	737
3.28.1	Structures Instrumentation	BRL	738
3.28.2	Pressure Measurements for Various Projects of Program Three	NOL	739
3.28.3	Pressure Measurements on Structures	SRI	740
3.29	Blast Effects of Atomic Weapons Upon Curtain Walls and Partitions of Masonry and Other Materials	FCDA	741
3.30	Air Blast Gage Studies	BRL	742
	Program 4 Biomedical Effects		
4.1	The Radiation Hazards to Personnel within an Atomic Cloud	AFCRC	743
4.2	Direct Air Blast Exposure Effects on Animals	NMRI	744
4.5	Flash Blindness	SchAvMed (RAFB)	745
4.7	Beta-Gamma Ratio in the Postshot Contaminated Area	Surg Gen	746
4.8	The Biological Effectiveness of Neutron Radiation from the Nuclear Artillery Shell in Free Air and in Foxholes	NRDL	747



Project No.	Title	Agency	WT No.
	Program 5 Aircraft Structures Test		
5.1	Atomic Weapon Effects on AD Type Aircraft in Flight	BuAer	748
5.2	Atomic Weapon Effects on B-50 Type Aircraft in Flight	WADC	749
5.3	Blast Effects on B-36 Type Aircraft in Flight	WADC	750
	Program 6 Tests of Service Equipment and Operations		
6.2	IBDA Phenomena and Techniques	WADC	751
6.3	Interim IBDA Capabilities of Strategic Air Command	SAC	752
6.4	Evaluation of Chemical Dosimeters	ACC	753
6.7	Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations	SCEL-ESL	754
6.8	Evaluation of Military Radiac Equipment	SCEL-BS	755
6.8a	Initial Gamma Exposure Vs Distance	SCEL	756
6.9	Evaluation of Naval Airborne Radiac Equipment	BuAer	757
6.10	Evaulation of Rapid Aerial Radiological Survey Techniques	SCEL	758
6.11	Indoctrination of Tactical Air Command Air Crews in the Delivery and Effects of Atomic Weapons	TAC	759
6.12	Determination of Height of Burst and Ground Zero	AFF, ESL	760
6.13	Effectiveness of Fast Scan Radar for Fireball Studies and Weapons Tracking	NEL	761
	Program 7 Long-range Detection		
7.1	Electromagnetic Effects of Nuclear Explosions	AFOAT-1	762
7.3	Detection of Airborne Low Frequency Sound from the Nuclear Explosions	AFOAT-1	763
7.4	Seismic Measurements	AFOAT-1	764
7.5	Calibration Analysis of Close-in A-Bomb Debris	AFOAT-1	765
	Program 8 Thermal Measurements and Effects		
8.1a	Effects of Thermal and Blast Forces from Nuclear Detonations on Basic Aircraft Structures and Components	WADC	766
8.1b	Additional Data on the Vulnerability of Parked Aircraft to Atomic Bombs	WADC	809
8.2	Measurement of Thermal Radiation with a Vacuum Microphone	AFCRC	767
8.4-1	Protection Afforded by Operational Smoke Screens Against Thermal Radiation	ACC	768
8.4-2	Evaluation of a Thermal Absorbing Carbon Smoke Screen	ACC	769
8.5	Thermal Radiation Protection Afforded Test Animals by Fabric Assemblies	QtrmR&DL	770
8.6	Performance Characteristics of Clothing Materials Exposed to Thermal Radiation	QtrmR&DL	771
8.9	Effects of Thermal Radiation on Materials	NMRL	772
8.10	Physical Characteristics of Thermal Radiation from an Atomic Bomb Detonation	NRDL	773
8.11a	Incendiary Effects on Building and Interior Kindling Fuels	Forestry Service	774
8.11b	Ignition and Persistent Fires Resulting from Atomic Explosions Exterior Kindling Fuels	Forestry Service	775
8.12a	Sound Velocities Near the Ground in the Vicinity of an Atomic Explosion	NEL	776

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Project No.	Title	Agency	WT No.
8.12b	Supplementary Pressure Measurements	David Taylor Mod. Bas.	777
8.13	Study of Fire-retarding Paint	ERDC	778
	Program 9 Technical Photography		
9.1	Technical Photography Final Report	AFSWP	779
9.6	Production Stabilization	Waterways Experimental Station	780
9.7	Experimental Soil Stabilization	Waterways Experimental Station	781
	Program 10 Gamma-ray Measurements		
10.1, 10.2a	Alpha and Transit-time Measurements on [redacted] Tests	UCRL-Livermore	708
10.1	Alpha and Transit-time Measurements	EG&G	807
10.2b	Remote Transit-time Measurements	Sandia	
10.3	Total Gamma Vs Distance with Film Badges	LASL	
10.4	A Measurement of Teller Alpha	LASL	706
10.4	Investigation of an Alpha Telemetering System	LASL	799
	Program 11 [redacted] Investigations		
[redacted]	Investigations	LASL	
	Program 12 Technical Photography		
12.1	Technical Photography	EG&G	
12.1	Bhangmeter Mod II	EG&G	788
12.2	High-speed Photography	LASL	
	Program 13 Radiochemistry		
13.1	Radiochemical Studies	LASL	
13.2	Radiochemical Measurements by UCRL for Upshot	UCRL-Livermore	
	Program 14 [redacted] Measurements		
14	[redacted]	LASL	818
	Program 15 Electromagnetic Investigations		
15.2	Measurements of Electric Transients in the Earth	Sandia	813
15.3	A Survey of Electromagnetic Effects Observed during Upshot	UCRL-Livermore	797
15.4	Investigation of Early Electromagnetic Signals	LASL	791
	Program 17 Neutron Measurements		
17.1	Integral Neutron Measurements (Threshold Detectors)	LASL	
17.2	Neutron Spectrum Measurements (Nuclear Emulsion Plates)	LASL	
17.3	Tenex	LASL	
17.4	Neutron Energy Distribution on [redacted]	UCRL-Livermore	804

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Project No.	Title	Agency	WT No.
	Program 18 Thermal Radiation		
18.1, 2, 6	Thermal Radiation Measurements: Part I—Total Thermal Radiation and Air Attenuation; Part II—Power as a Function of Time (Photocells); Part III—Surface Brightness Investigations (Bowens & Slits)	NRL	
18.3	A Preliminary Survey of High Dispersion Spectrograms Obtained at Upshot-Knothole	NRL	
18.4	Light Absorption Characteristics of Region Surrounding Fireball	NRL	
18.5	Doppler Shift Investigations of Case Motion	NRL	
	CIVIL EFFECTS STUDIES		
	Program 21 Civil Defense Effects		
21.1	Effects of an Atomic Explosion on Underground and Basement Types of Home Shelters	AEC-FCDA	801
21.2	Effects of An Atomic Explosion on Two Typical Two-story-and-basement Wood-frame Houses	FCDA	792
21.3	Air-zero Locators	FCDA	
	Program 22 FDCA Radef and Radiation Effects		
22.1	Evaluation of Training Program for Radiological Defense Personnel	FCDA	808
22.2	Various Aspects of Nuclear Radiation Measurements for Civil Defense Radiological Defense Purposes	FCDA	805
22.3	Radiological Hazards in Civil Defense	FCDA	
22.4	Exposure of Drugs to Nuclear Explosions	FDA	810
	Program 23 Biomedical Experiments		
23.1	Biological Effectiveness of Ionizing Radiation within Shelter	NRDL	793
23.2	Bacteriological Studies on Animals Exposed to Neutron Radiation	NRDL	794
23.3	Long-Term Studies on Dogs Exposed to Primarily Neutron Irradiation in Shelters	NRDL	
23.4–23.14, 23.16	Genetic Effects of Fast Neutrons from Nuclear Radiations	AEC	820
23.15	Effects of Overpressures in Group Shelters on Animals and Dummies	Lovelace Clinic	798
23.17	Neutron Flux Measurements in AEC Communal Shelters and Lead Hemispheres	NRDL	795
	Program 24 AEC Shelter Structures		
24.1	Evaluation of Communal Shelters	AEC	
24.2	Physical Measurements of Gamma and Neutron Radiation in Shelter and Instrumentation Evaluation	AEC	789
24.3	AEC Shelter Instrumentation	Vitro	790

Project No.	Title	Agency	WT No.
	Program 26 Civilian Vehicle Tests		
26.1, 26.2	Physical, Mechanical, and Irradiation Evaluation of Civilian Vehicles Exposed to Atomic Attack	AEC-FCDA	
	Program 27 Fall-out Studies in Near Areas		
27.1	Distribution and Characteristics of Fall-out at Distances Greater Than Ten Miles From Ground Zero, March and April 1953	UCLA-AEP	811
27.2	Environmental and Biological Fate of Fall-out From Nuclear Detonations in Areas Adjacent to the Nevada Proving Grounds	UCLA-AEP	812
	Program 28 Radiation Telemetering System		
28.1	Test of a Radiation Telemetering System	AEC	796
	Program 29 Dosimetry and Radiation Measurements		
29.1	Comparison and Evaluation of Dosimetry Methods Applicable to Gamma Radiation	UCLA	802
29.2	Fast Neutrons Effects on Semi-conductors	UCLA	803
29.3	Evaluation of Dosimetry for Civil Effects Programs	AEC	
29.4	Effective Energy of Residual Gamma Radiation	U. Rochester	814